



# Efficient Power Conversion

Value 3

**So who cares about efficiency really?**

## Gold Servo Drives Outstanding Capabilities

- Best results with Any Servo Load, even for the most demanding nonlinear, high resolution system mechanics.
- Fully automated, ultimate tuning tools, accomplishes top performance "fast & easy"
- Widest range of sizes, operating voltages, output currents, feedbacks
- Lowered to a 50µs sampling rate at all servo loops
- "1:1" technology, same sample time for current, velocity and position loops resulting in very high bandwidths and robust stability margins
- Current Loop bandwidth as high as 4.5KHz
- High and flexible Control Loop order to deal with any mechanical dynamic system characteristic
- Very high linearity, current dynamic range of 2000:1 (100A drive smoothly runs a 0.05A load)
- Supports any "known" feedback sensor (Incremental Encoders, analog (sine/cosine) and Resolvers with high precision, high resolution, built-in multiplier, 2- and 3-Phase absolute Analog Halls, absolute Serial Encoders).
- Any feedback sensor combination of Dual Loop architecture, with flexible configuration of feedback organization via Elmo's unique and advanced Sensor Socket interfaces
- 2 in 1, a drive can simultaneously control two independent motors using 2 advanced independent motion profilers
- Mastering gantry using only 2 Gold drives - no need for additional bulky controller
- By-the-book standard EtherCAT and CANopen networking capability
- Abundance of control and profiling features:
  - ECAM / Follower
  - Output Compare / PEGS
  - Master-Slave Current / Position Follower
  - Modulo
  - Dynamic Braking
  - Dual Loop
  - Gantry / Planar
  - Unlimited Control Numerical values
  - High order control Filter Structure
  - Advanced Scheduled Filters Support with multiple scheduling strategies: By Position, By Reference Velocity, By Actual Velocity, For Best Settling, Manual Scheduling, and From
- Network
  - **Utmost efficiency of up to 99%**
  - Ultra High Current technology
  - Certified Safe Torque Off (STO)
  - Complies with Safety, EMC and Environmental standards
  - Proven reliability of MTBF > 10<sup>5</sup> Hours

EtherCAT  
Conformance tested  
CANopen



07

## Reference Velocity, By Actual ve Network

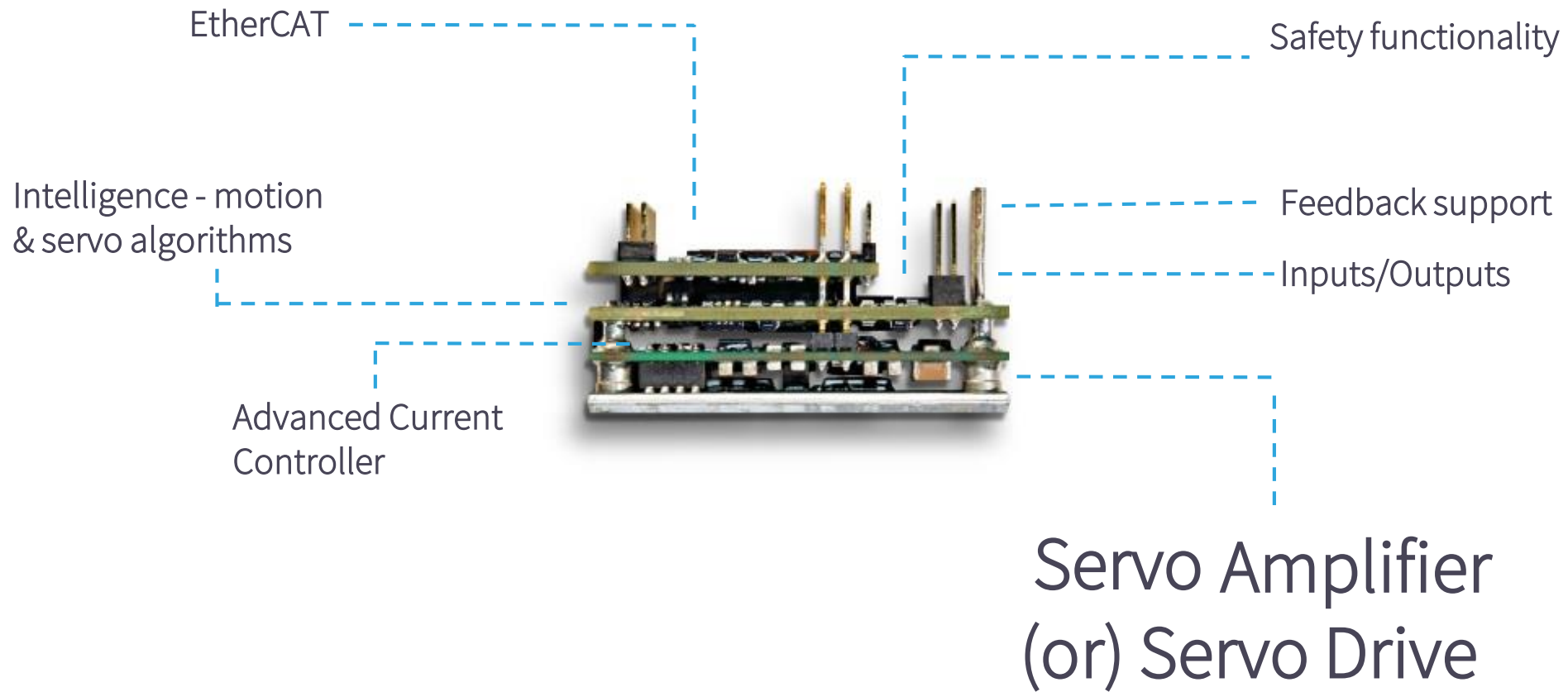
- Utmost efficiency of up to 99%
- Ultra High Current technology

# Ultra Hi Efficiency

**Elmo servo drives are over 99% efficient in switching, which has huge implications on:**

- Size
- Heat
- EMI
- Performance

# Servo drives are about **power conversion** (but not only).



# Qualitative Power

*Qualitative Power is the capability to deliver to the load exactly the power required, “None Less, None More”.*

Unforeseen and undesirable power transmissions to the mechanical load (excessive or insufficient)  
Is **Noise** which creates electrical and mechanical “pollutions”

Power Conversion  
Inefficiency



Excessive  
Heat

EMI

Torque Generation  
Inefficiency



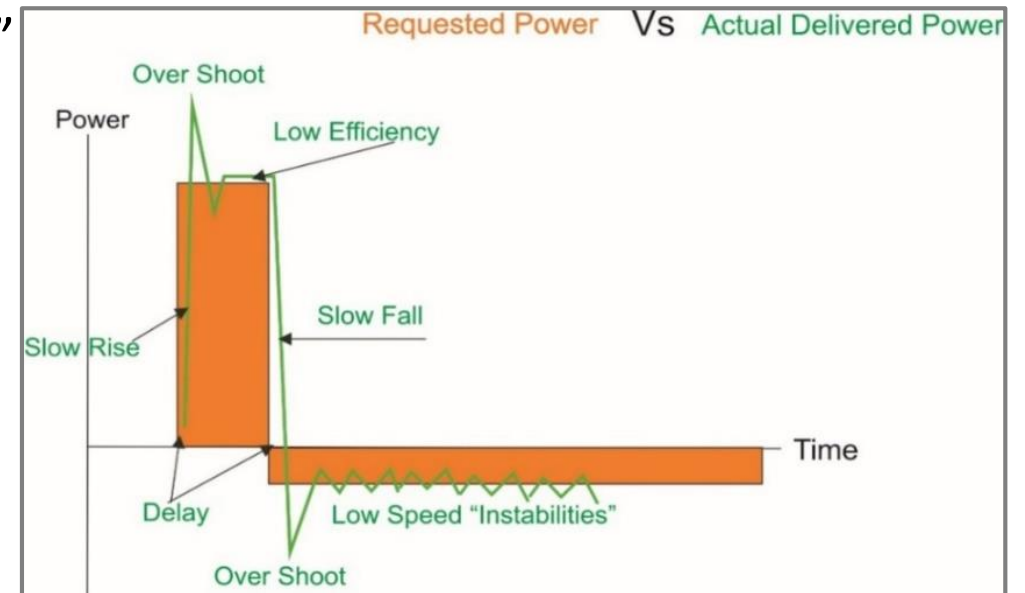
Torque Ripple &  
Non-linearities

Moving the  
Load  
Inefficiency



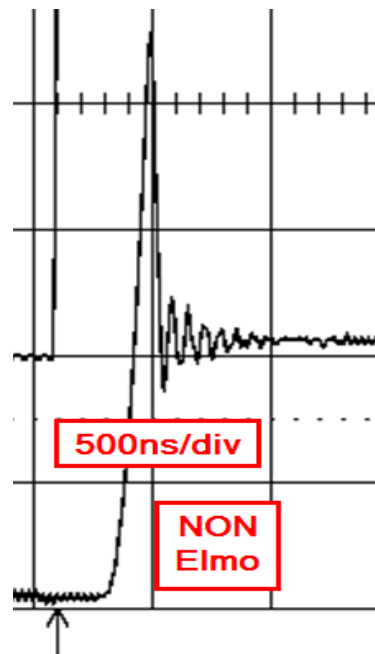
Mechanical  
Resonance

Motion Control



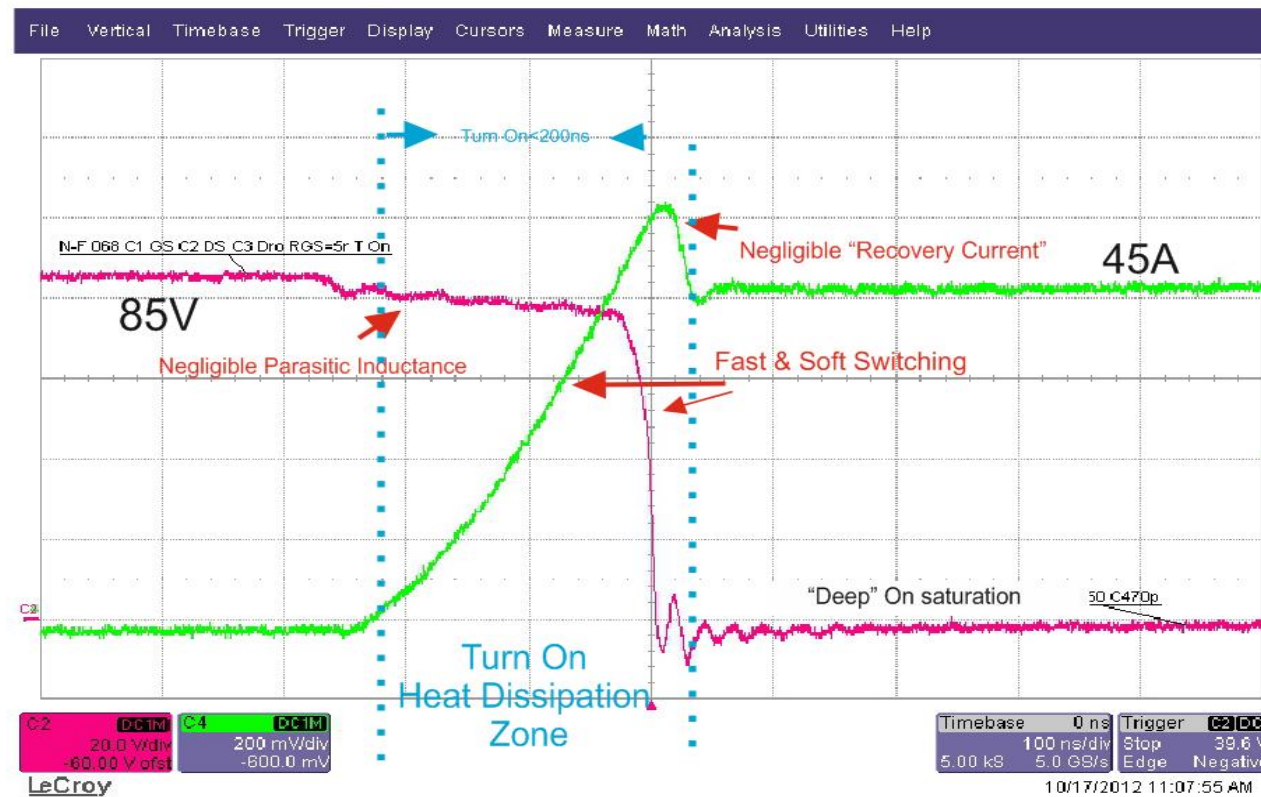
# Ultra Hi Efficiency, FASST

## Turning On



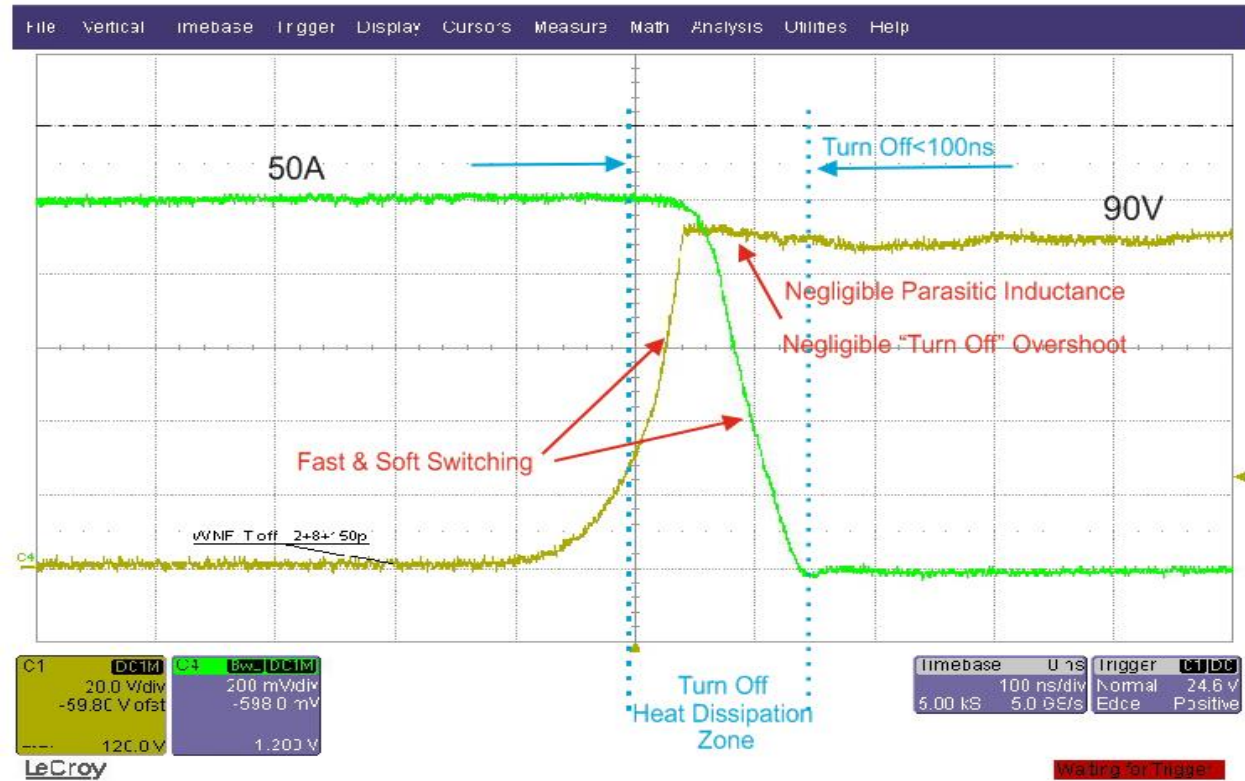
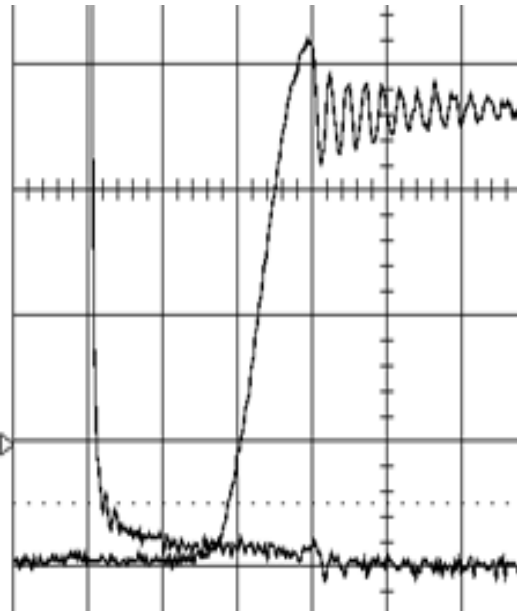
### Turn ON

Perfect PWM switching system which is very fast (<200 ns), deep ON saturation, highly efficient, and yet with very low stress and negligible EMI (very low recovery current).



# Ultra Hi Efficiency, FASST

## Turning Off

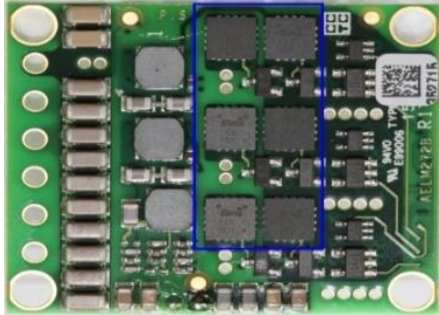


### Turn OFF

The perfect PWM switching system is very fast ( $<100$  ns), deep ON saturation, very efficient, and yet with very low stress and negligible EMI (no voltage overshoots)  
The servo drives exhibit superior efficiency.



# Fast And Soft Switching Technology (FASST)



The dramatic performance is carved from the “Generation II” of Elmo ASIC,

The FID is a proprietary controller for power devices.

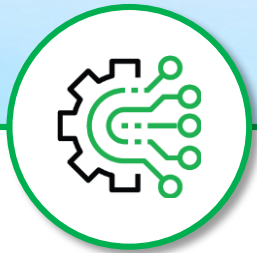
The FID fully controls the PWM process, stronger, faster and yet “stress-free” and very “soft”.

The FID optimizes all 4 states of the PWM Power conversion:

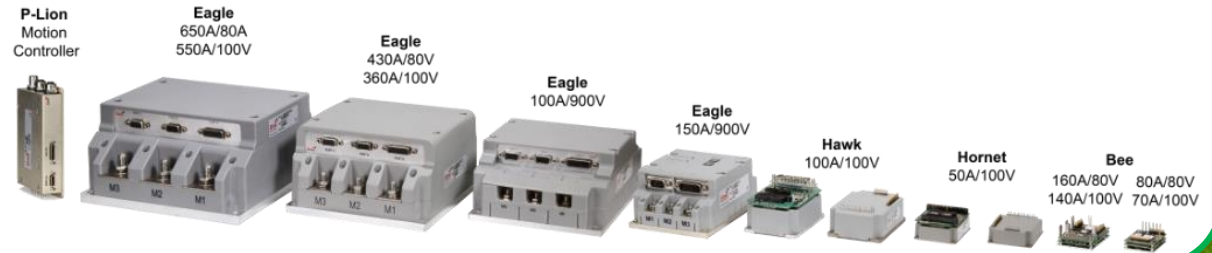
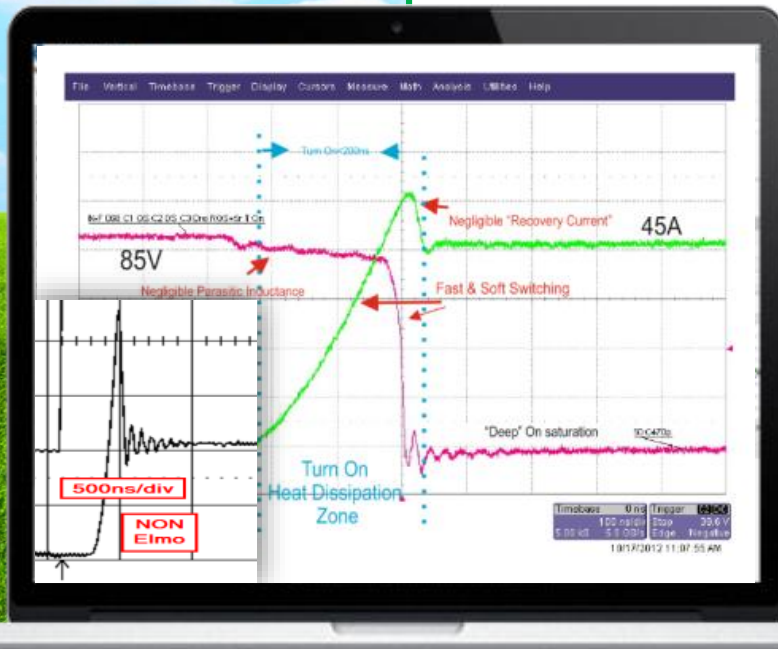
- OFF State
- Turn On
- On State
- Turn Off

# GREEN Motion Control

## Efficient Power Conversion



Elmo servo drives are **99% efficient** in power conversion | **Minimal heat** generated | **Minimal EMI** |



Elmo's proprietary FASST  
PWM switching technology

# High Efficiency – Negligible EMI

Creating High EMI can be resolved by bulky power dissipating filters, Inductors, capacitors,....

Elmo's unique Fast and Soft Switching Technology significantly reduces the **EMI** typically created by PWM drives.

In most applications, with Elmo servo drives there is no need for additional external means (such as filters) to meet **EMC** requirements.



# High Efficiency = Less heat created

## 6.13.2 Heat Dissipation Data

Heat Dissipation is shown graphically below in Figure 43 and Figure 44.

It should be noted that no external heatsink is required for power dissipation less than 20 W.

For higher power, the Gold DC Trombone should be mounted on the application chassis.

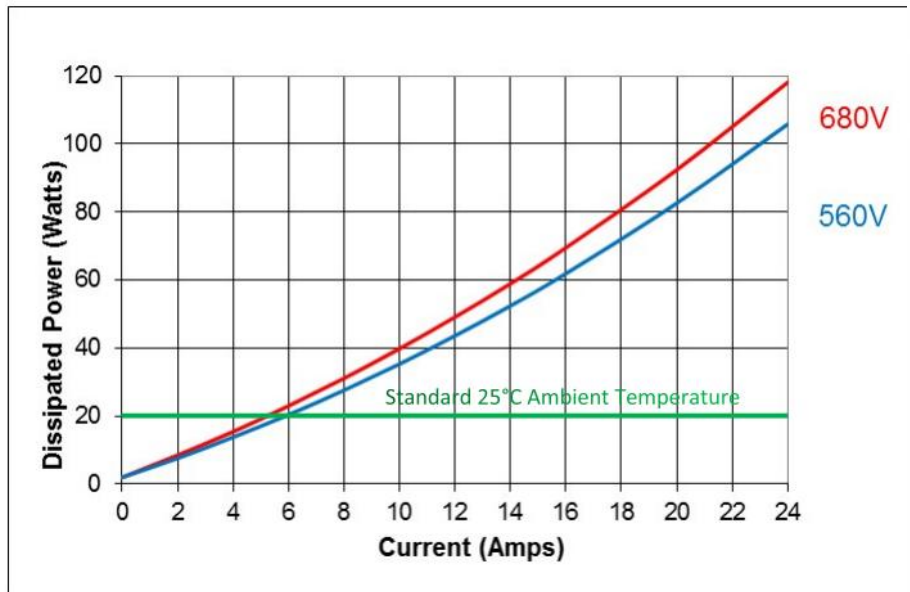


Figure 43: Dissipation versus Current Graph for 560 and 680 VDC for Standard L-Shape Heatsink



Low efficiency results in more heat which means:  
heat-sinks, fans, cooling means...



# Power & Intelligence Density

Value 4



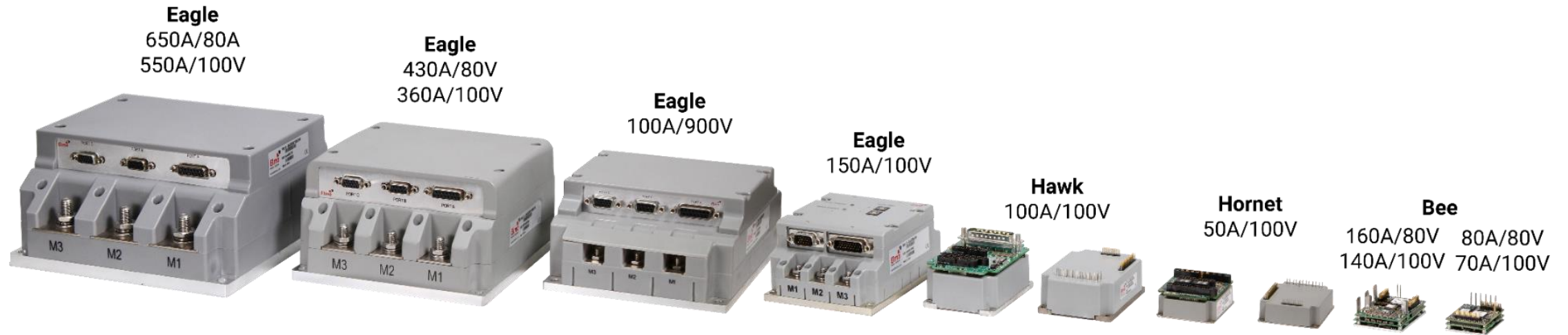
# What is “Power Density”?

“Power Density” is a ratio representation of the output power available from the drive, to the volume of the drive.

Power/Volume  
Watt/cm<sup>3</sup>



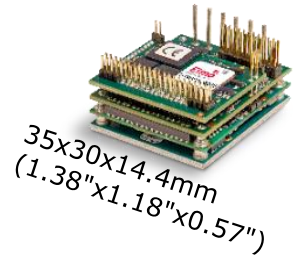
# High power density on all Elmo drives.



This is because all Elmo drives use the same ultra efficient switching (FASST), and each is capable of delivering impressive power for its size.

# Maximum Continuous Power Output

5kW



35x30x14.4mm  
(1.38"x1.18"x0.57")

**Gold Twitter R80/80**  
(G-TWIR80/80)

25kW



160x180x90(6.30"x7.09"x3.54")

**Gold Drum R430/80**  
(G-DRUR430/80)

65kW



180x142x75.2 (7.08"x5.53"x2.96")

**Gold Drum R100/800**  
(G-DRUR100/800)

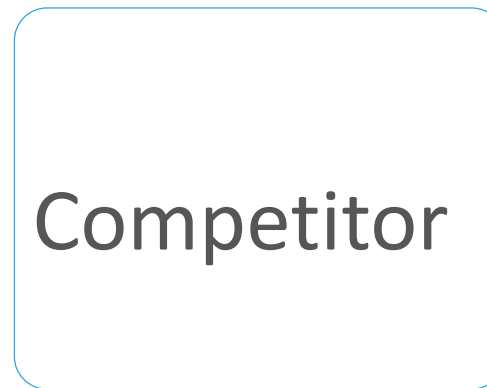


# What's the big deal with power density?

“Anyone” can be small. But what do you do with that size is the real questions.



50VDC Bus Voltage  
50A Drive Output  
**18W dissipation**

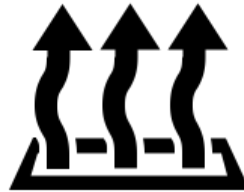


50VDC Bus Voltage  
50A Drive Output  
**120W dissipation**

# What's the big deal about being small?



**Efficiency:** Top Power Conversion efficiency is critical for very high power density devices while keeping performance, safety and reliability.



**Heat Expelling:** the little heat created must be expelled out of the drive rapidly and in the shortest way.



**Temperature Sensing:** Real time, fast response and precise temperature sensing is mandatory for the “Thermal management” of the drive.



**Control:** “Enormous Amount” of Functions, Capabilities, Features, powerful processing, logic, ...

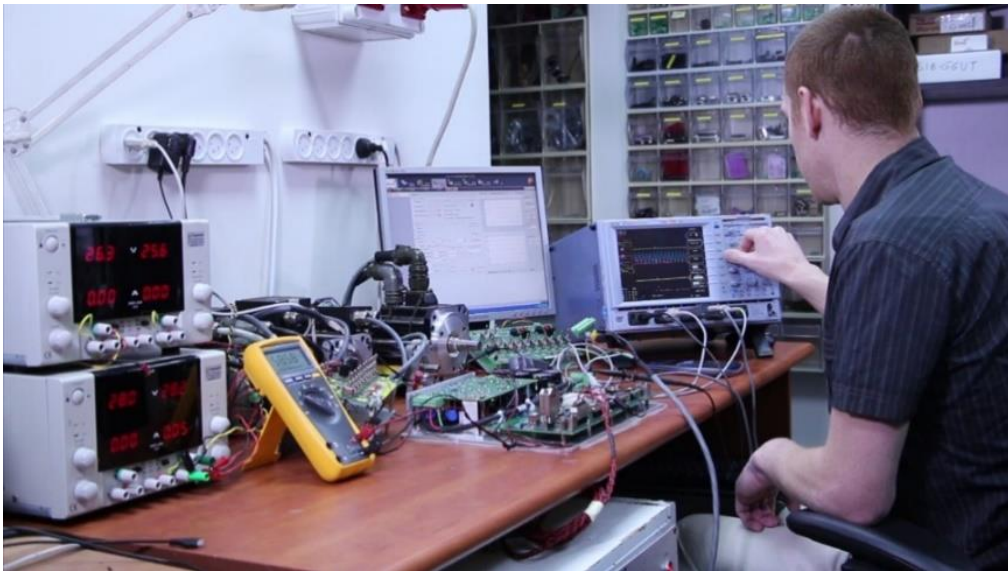


All the above must be realized while keeping utmost **Quality, Safety, EMC, Productivity**

The challenge that must be accomplished result in “Very high power out of an Ultra small package”:

# How do we do it?

Elmo's power density is made possible through:



Industry leading design  
technologies and engineering



State Of The Art manufacturing  
Technologies



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# Any Voltage, Any Current, Any Power

Chapter 4.2

# Any Voltage

Range: **10 – 900VDC / 30-530VAC**

Some highlights:



**Gold Mandolin 400V**



**Gold Tuba 530VAC**



**Gold Drum HV 900V**

# Any Voltage – DC Input Drives (some)



**G-SOL-TWI**  
8-194VDC



**G-Cello**  
14-195VDC



**G-DC-  
Trombone**  
50-780VDC



**G-Drum HV**  
50-800VDC  
(900VDC in G-  
EAG HV)

# Any Voltage – AC Input Drives (some)



**G-Oboe**  
50-230VAC  
140-480VAC



**G-Tuba**  
60-230VAC  
140-480VAC



**Basson  
(SimplIQ)**  
30-270VAC



**Cornet  
(SimplIQ)**  
60-270  
140-505VAC

# Any Voltage

## The Tambourine

A compact, direct-to-mains **power supply** for servo applications, up to 530 VAC

Power supplies for **servo applications** must have:

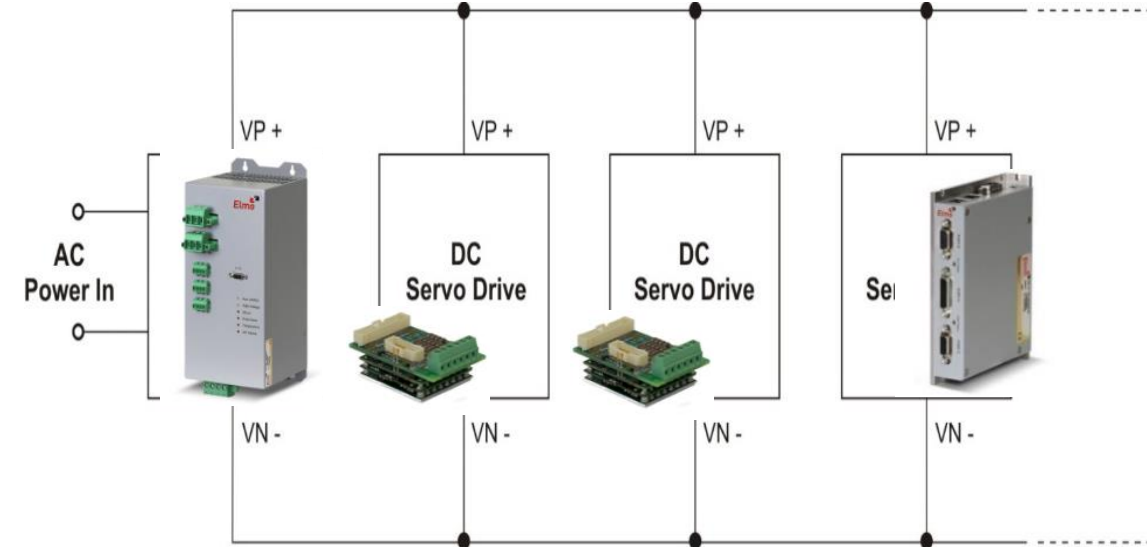
- adequate DC Bus
- sufficient power resources to drive the loads
- voltage variations within acceptable limits
- bi-directional energy flow
- high-frequency power handling



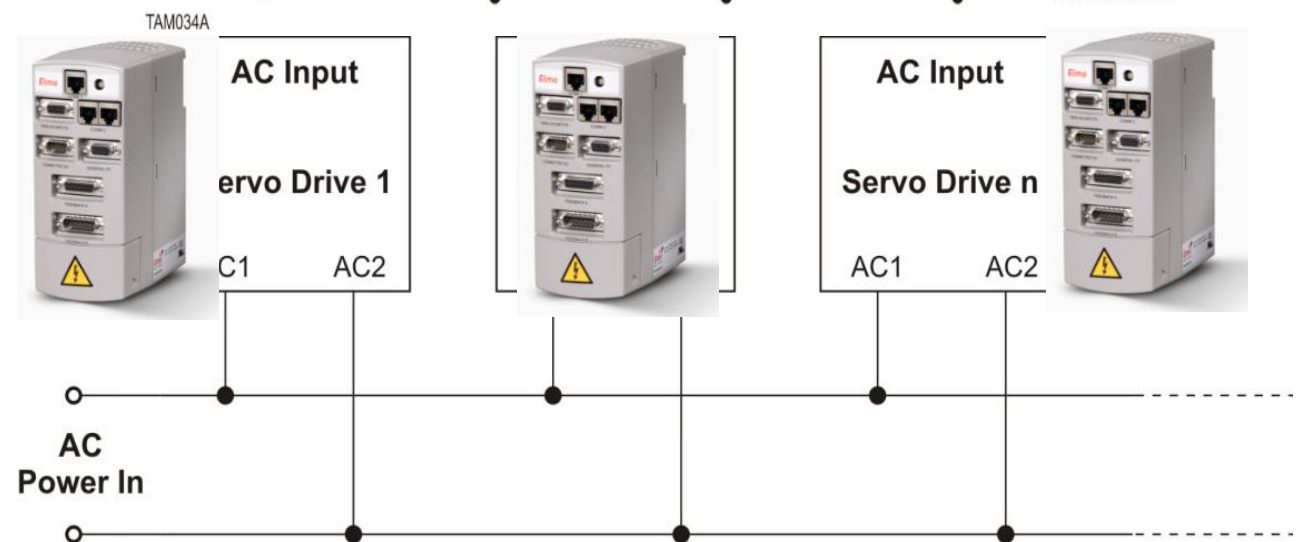


# Two Basic Topologies:

1. Shared DC Bus  
(common DC bus)



2. AC Common  
Power Bus



# Shared DC Bus

Elmo recommends a **shared DC Bus** in any application with a number of axes  $>2$ .

## Advantages include:

- Sharing the power Bus resources
- Compact
- **High efficiency - Regeneration sharing**
- Sharing the safety, protections, EMI, etc.
- Saving cost (1 rectifier , 1 shunt, ...)



# 'R' Type Elmo Servo Drives



What is **R**? In some applications there is a need for high current for longer time than the traditional  $I_p$  ( $\approx 3\text{sec}$ ).

In The R high output current is only by the temperature protection. This means Hi Current for a very long time, much longer that the  $I_p$  duration.



Current Vs Time comparison (Traditional and R type)





$I_c$ - Drive Continuous current  
 $I_p$ - Drive Peak current

Feature	Units	R50/60	R45/100	R15/200
Minimum supply voltage	VDC	8	10	20
Nominal supply voltage	VDC	48	85	170

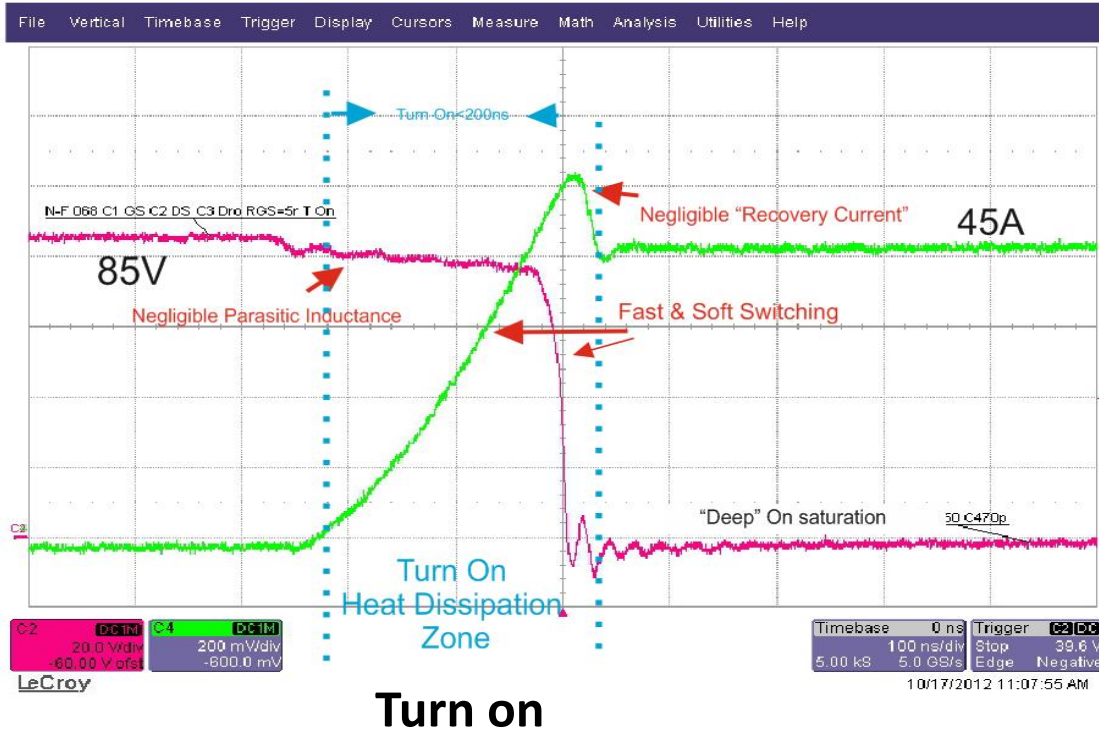
# Thermal Management

## Gold DC Trombone example

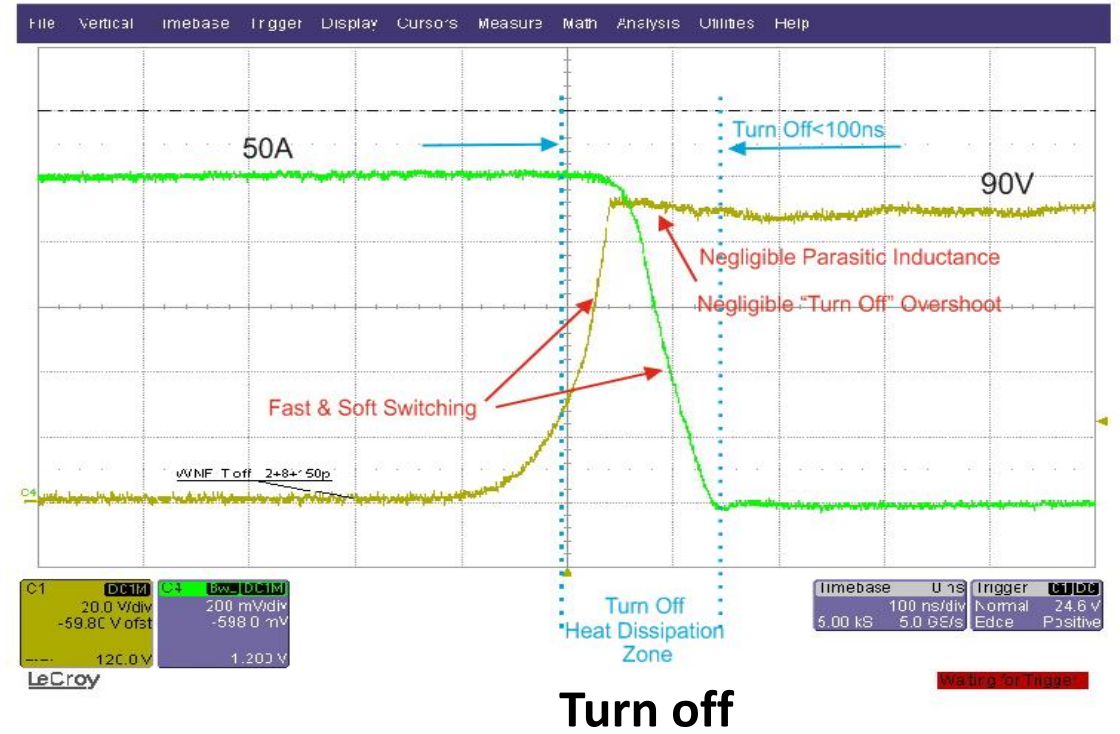
- Isolated thermally, only 3.6 Amps can be drawn
- Simple Cabinet's steel attachment doubles to 6.3A
- Simple Cabinet's aluminum attachment and up to 9A
- Simple Wide Side mounting and the full 12A is achieved

	Thermally Isolated (Stand Alone)	Thermally Non Isolated on Steel Chassis	Thermally Non Isolated on Aluminum Chassis	Thermally Non Isolated on Aluminum Chassis (Flat)
L-Shape Only	Max current capability for $\Delta T=45^{\circ}\text{C}$ , $I_C=3.6$ Amp. 	Max current capability for $\Delta T=46^{\circ}\text{C}$ , $I_C=6.3$ Amp. 	Max current capability for $\Delta T=44^{\circ}\text{C}$ , $I_C=9.0$ Amp. 	Max current capability for $\Delta T=41^{\circ}\text{C}$ , $I_C=12.0$ Amp. 

# Reducing EMI through FASST



Turn on



Turn off



With Elmo's FASST technology keeps the process "soft" and with no stress to the power device. The results are low EMI.

**Name your challenge!**

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Thank You!