P R

B X

POWERBOX
Mastering Power

”One Step Conversion”

Concerns when selecting
AC/DC power supplies

# Concerns when selecting power supplies

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VP – Product Management

Martin Fredmark joined Powerbox in 1995, with a break 2002 to 2005. He has held management positions in several areas, as supply chain, product management and business development. The last five years prior to his current position he was Director and Business Unit Manager for Powerbox Standard Products. He has more than 20 years of power supply experience, in particular within the Medical and Industrial sectors.

# Concerns when selecting power supplies

→**PFC functionality**

→**Superior EMC**

→**Peak power capacity**

→**Very low leakage current**

→**Low stand-by power**

→**Over temperature/load protection**

→**Low component count**

# ”One Step Conversion”

Our designers have used flyback topology for more then 30 years and perfected the behavior of the basic topology.  Medline 80 & 100

During 2010 an internal project was launched to further enhance and evolve the technology based on Valley-fill with flyback step down

This has now given Powerbox a new platform to generate unique Standard products as well as customized versions for applications within:

Industrial

Medical

Transportation

Defense

# Main features & values

| *Feature* | *Value* |
|---|---|
| PFC functionality | Conformity to international standards |
| Superior EMC performance | Faster & simplified design-in & certification of customers system |
| Very low leakage | Wide range of applications plus faster and simplified design-in and system implementation |
| Low zero load/stand-by | Conformity to international standards.<br>Environmental friendly. Low ”self-heating”. Simplified design-in |
| Intelligent OTP | Protection of PSU and the system it powers up. Enables peak power |
| Low component count | Reliability of both the product and sourcing of the product |
| Unique components limited | Reliable and sustainable sourcing – Limited need for updates of CB & Certifications |

# Power Factor Correction - PFC

# What is PFC functionality?


→Power Factor Correction & suppression of harmonics

→Power factor 1.0, equals to resistive load

→Harmonics is distortion current created by the load on the AC mains

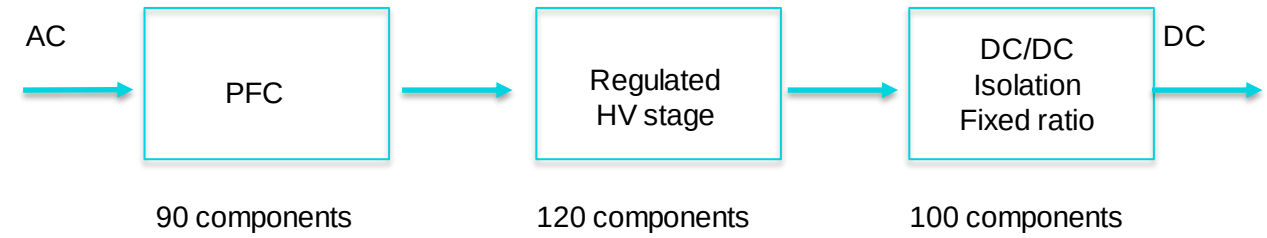
→Included in EMC requirement for CE marking

→Fulfillment of international standard IEC61000-3-2

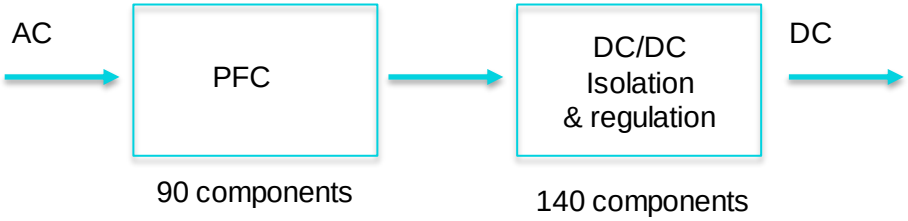
- A,B,C & D levels depending on application

# PFC functionality – One step Conversion

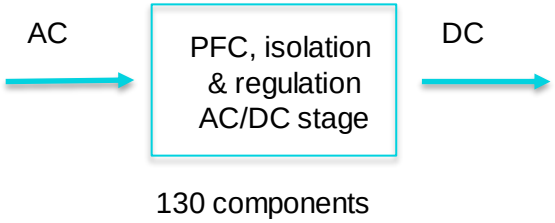
## Unique approach to gain PFC >90% with 30-40% less component compared to 2 or 3 step conversion




**3-step conversion**
Application note based, 3 chips
Approx 300 components
Unique/single
source components
Approx 8 W ZLC




**2-step conversion**
Application note based with 2 control chips
Unique/single source components
Approx 230 components
Approx 1W ZLC




**1-step conversion**
1 control chip
Approx 130 components
No single source components
Below 0.3 Watts ZLC

# PFC function – One Step Conversion

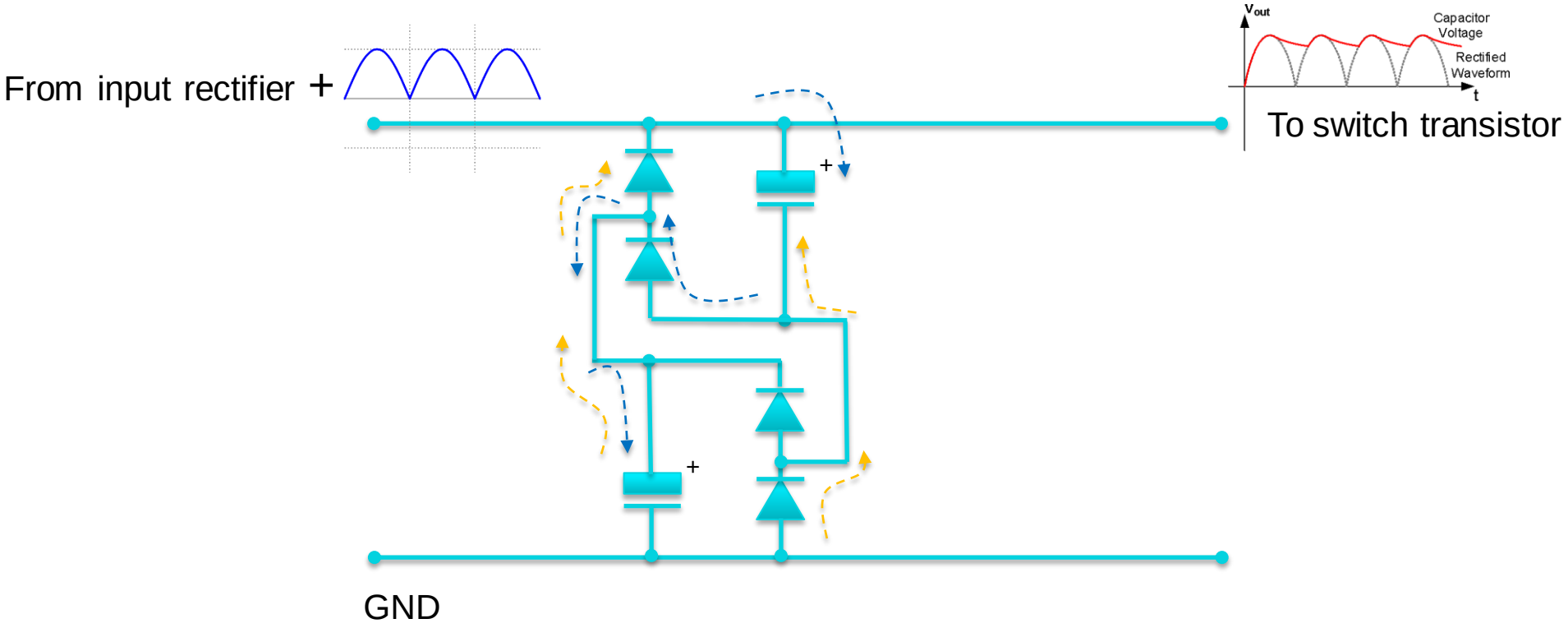
→Passive with diodes

- No active circuitry with separate control circuit to compensate

→Two input capacitors at the primary side of the power supply

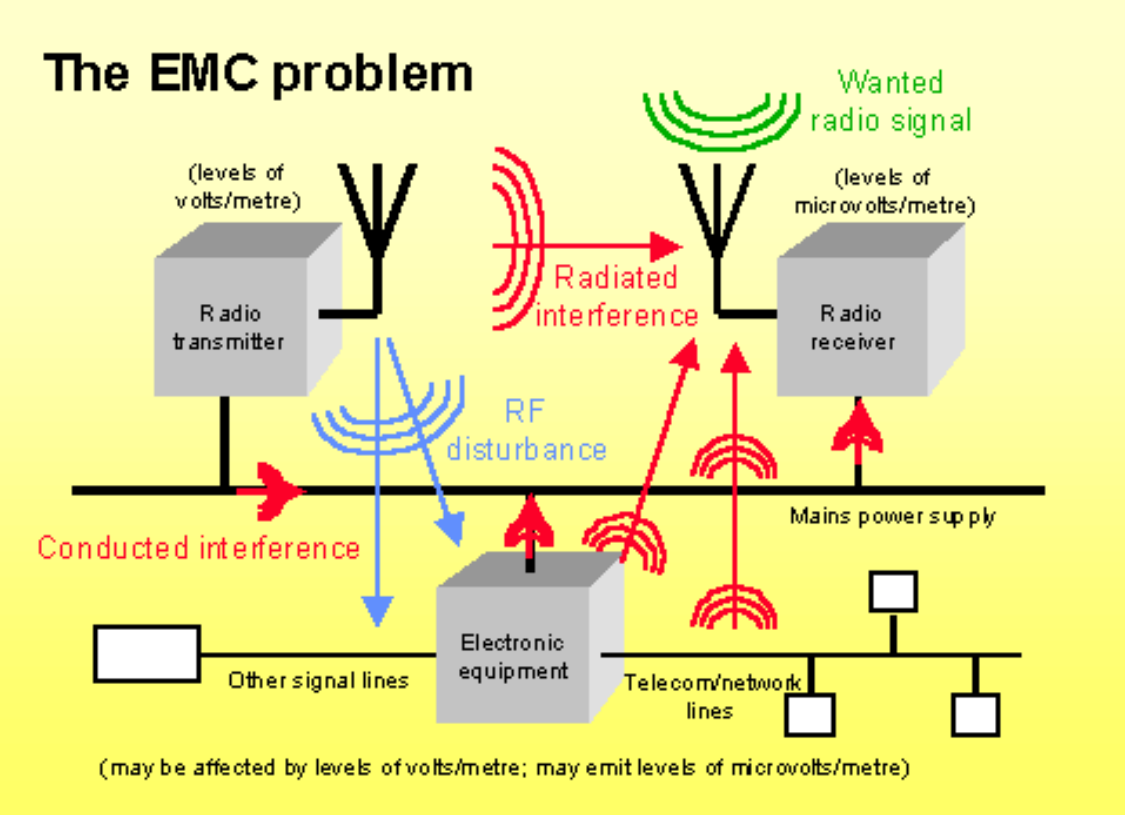
→Diodes handeling the charging/discharging of the capacitors

- In series during charging
- In parallel during discharging



# EMC/EMI

# What is EMC?




→Electro Magnetic Compatibility
- RFI (Radio Frequence Interference)
- EMI (Electro Magnetic Interference)

→Disturbances from and towards a product or a system

→Conducted
- Emmission
- Immunity (susceptibility)

→Radiated
- Emmission
- Immunity (susceptibility)

→In a switch mode power supply it origins from the switching

# How is low EMC reached?

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→EMC compatibility required for CE marking can be met by designing in two different ways or combinations thereof:

- Adding filters and supressors
- Balancing all aspects of the circuitry to reach optimum EMC performance

<u>Adding filters and supressors</u>

- Adds up component count
- Typically ferrites added
- Drives the unit cost
- Increases leakage current

<u>Balancing the circuitry</u>

- Time consuming
- Extensive experience and know-how
- Component placement
- PCB & Mechanical layout
- Focus on limiting EMC sources
- Compensate EMC sources
- Transformer design (sheilds, windings, core types)

# Peak Power

# What is peak power capacity?

→Boost power

→Extra power delivered during a limited time and with limited repetion rate (duty-cycle)

→**Some Examples;**

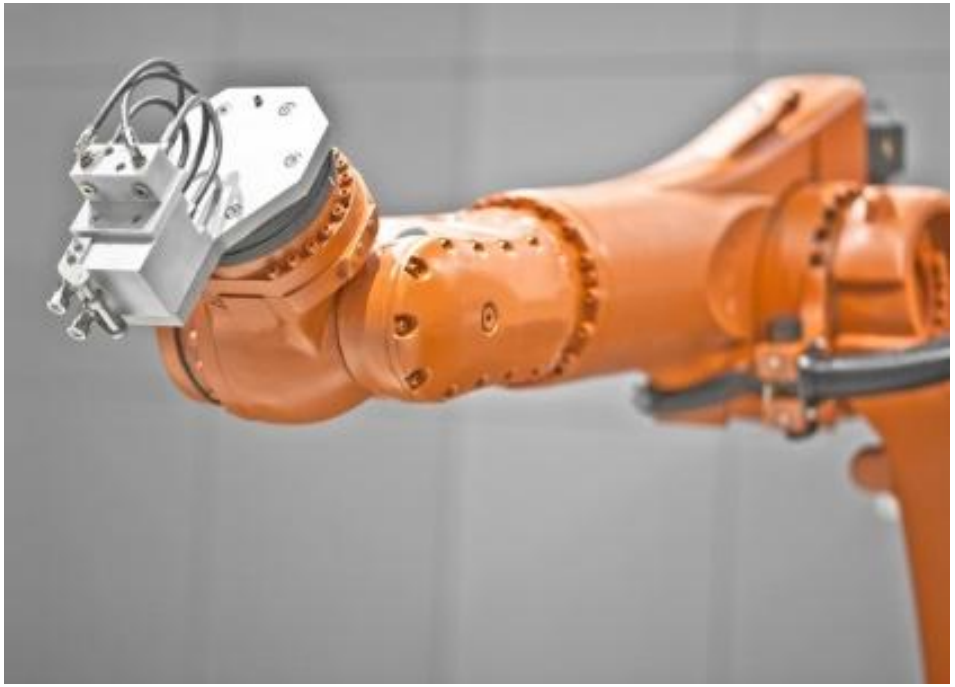
→Motors, drives

→Turbines

→Valves

→Heaters/Coolers

→Pumps



# How is peak power capacity achieved?

→Power conversion capacity of a power supply
  – Electrical
  – Thermal

→Electrically
→The OFM225 is designed to to provide up to 325Watts output power at 230VAC input
  – All components directly in the power conversion can handle the operating voltage and current without exceeding max allowed safe operating temperature for each component.
    • Input diode bridge
    • Input capacitors
    • Transformer
    • Output diode
    • Output capacitors

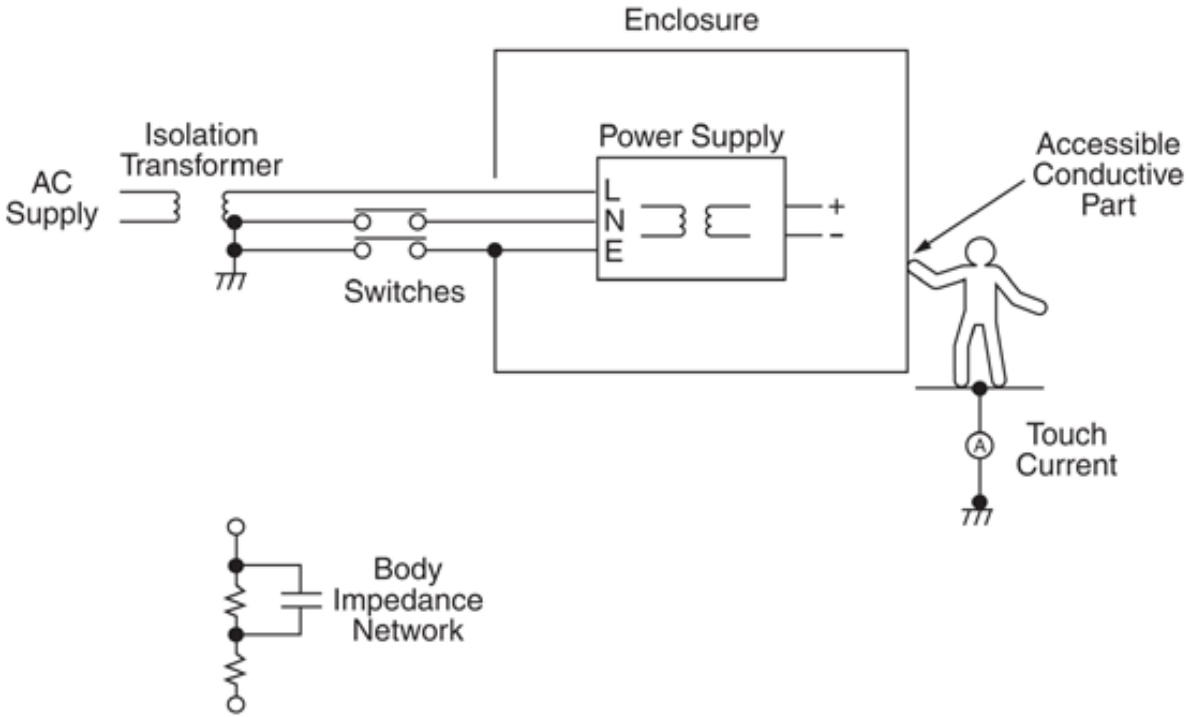
→Thermally
→The OFM225 requires forced air cooling to provide the 325 Watts continuously (100% duty-cycle)
→Alternatively without forced air cooling 325Watts with limited duration in time (10% duty-cycle)
  – This to allow enough cooling over time

# Leakage Current

# What is leakage current?

Leakage current

- Caused by the capacitances between Input and Output
- Conductive impurity deposition
- Stray capacitance
- EMI capacitance
- Ground potential difference
- Insulation materials aging




These capacitances are typically:

- Y-capacitors in input filtering
- Equivalent capacitance in transformer
- Y-capacitors between input-output

# How is low leakage current reached?

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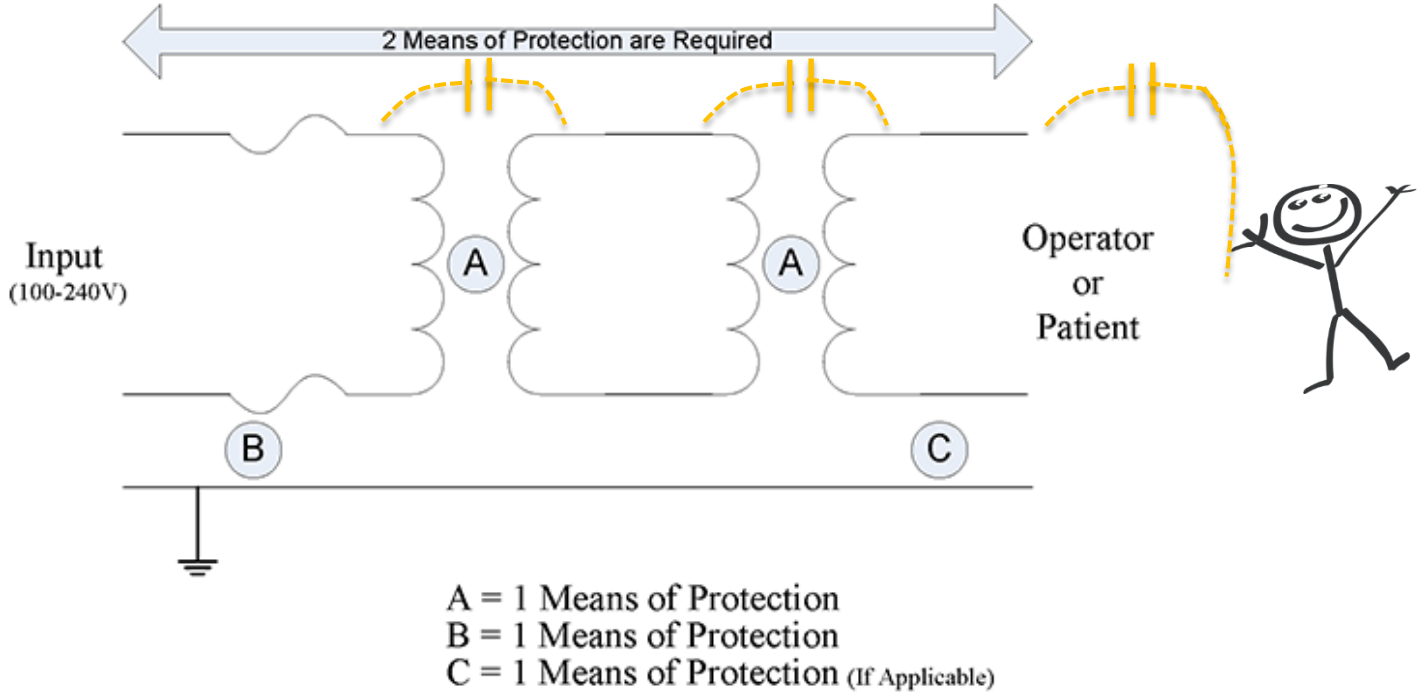
Power supply level
Minimum value of all Y-capacitances
Lowest possible equivalent capacitance in transformer
Low value of Y-cap generally increases EMC

System level
Additional isolation & barriers
No electrical connections accessible
Additional barriers



# Zero Load Consumption

# What is zero load consumption?

→ErP sets the limits for European levels of self consumtion when no load is attached to the output

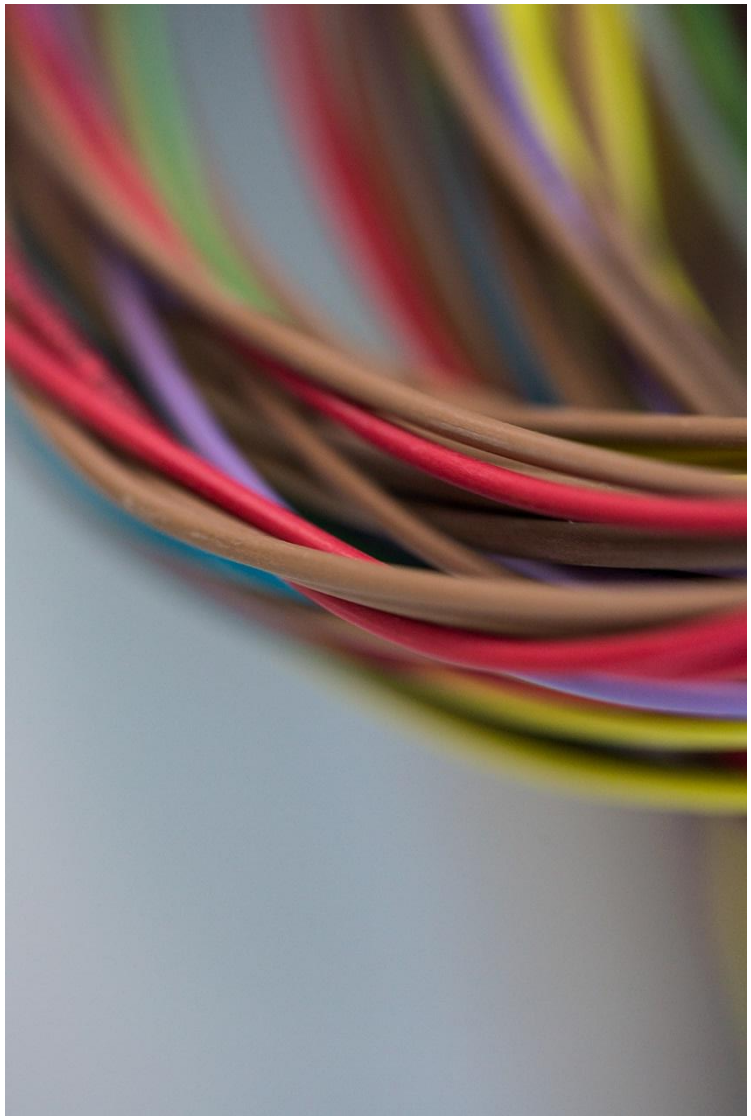
→European directive included in CE for Industrial,ITE & A/V equipment

→North America DOE (Department of energy) Level VI for ITE equipment

*Mandatory from February 2016*

| *Output power level on marking plate* | *Max allowed zero load consumption* |
|---|---|
| 1-49 Watts | 0.100 Watts |
| 50-250 Watts | 0.210 Watts |
| >250 Watts | 0.500 Watts |

# How is zero load consumption reached?



Using one step conversion…

→No active PFC circuitry

→Low quiscent current in internal ”house-keeping” circuitry, for example PWM controller

→Low value on X-capacitors on input

→Low switching frequency at zero load state

→Low zero load without switching off the PWM and feedback circuitry

→High efficiency already at low load condition

→Low component count

# Inteligent over temperature protection

# What is intelligent over temperature protection?

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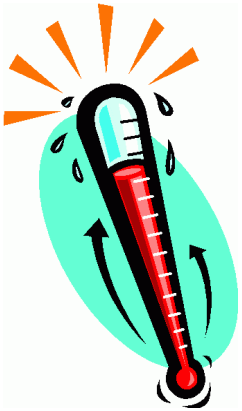
→Sensing of operating temperature close to the transformer

→Automatic limitation of output power when temperature reaches max allowed temperatures for critical components in the power supply ”graceful decline”

→Activation equal to overcurrent protection with reduction of output voltage

→Auto recovery

→Allowing peak power output as long as the temperature is within safe operation



# How is intelligent over temperature protection implemented ?

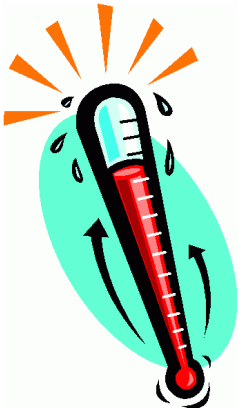
P R
B X

→Separate circuitry operating in parallell to the output current limiting circuitry

→Sensing component (NTC) located on PCBA close to the transformer

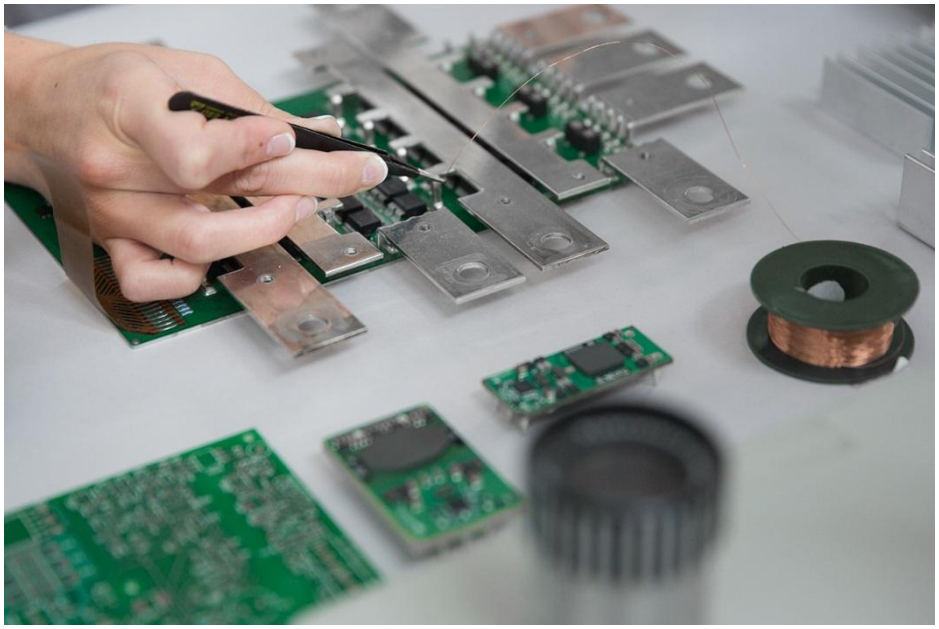
→Value of NTC is temperature dependant and sends continuously gives input to PWM control chip regarding the operating temperature.

→The PWM controling the switching limits the available output power in relation to the temperature



# Low Component count

# How is low component count reached?



→Combination of:

- Component lean topology
- One-step conversion
- Smart EMC balancing of the design

→Minimum usage of unique components

- PWM control

# Summary

# Pros and Cons of One Step Conversions

## Advantages

- High efficiency
- High power factor from AC mains
- Power factor correction without separate switching circuity
- Low component count
- Fault proof
- High power factor at all load conditions
- High power factor at all input voltage level conditions
- Built in transient protection
- Low stand by consumption
- Superior EMC
- Peak power capabillity
- Patented topology

## Limitations

- Increasing output ripple with low input voltages in combination with high output load
- Complex topology to master
  - Powerbox one of the few who can handle
  - Ripple/EMC/Leakage current/Audible noise tightly intermingled
- PF up to 0.95

## Benefits in applications

- High power factor from AC mains
- System reliability
- Cost efficient power factor correction
- Reliable
- Peak power capability
- High isolation/Low leakage
- EMC performance

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B X

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