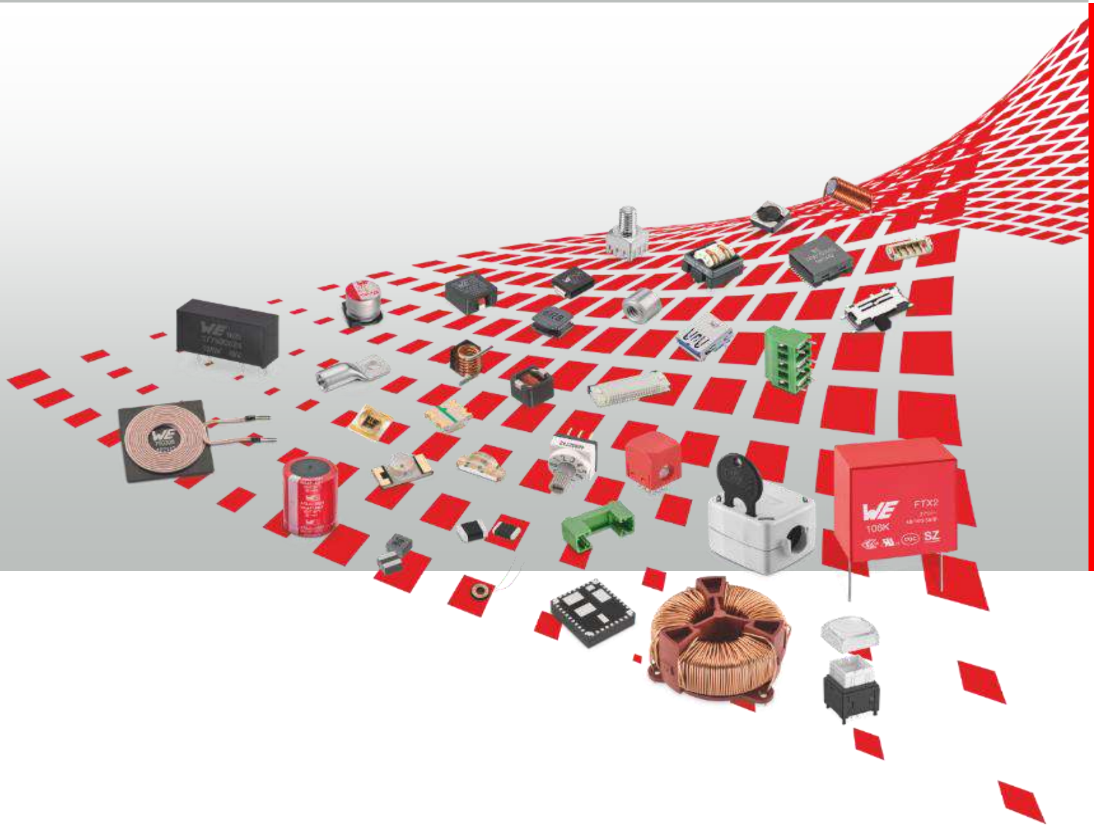
TECHNICAL ACADEMY

WÜRTH ELEKTRONIK

Web-Séminaire
« Récupération d’énergie pour les petits systèmes »
7-8 juillet 2020

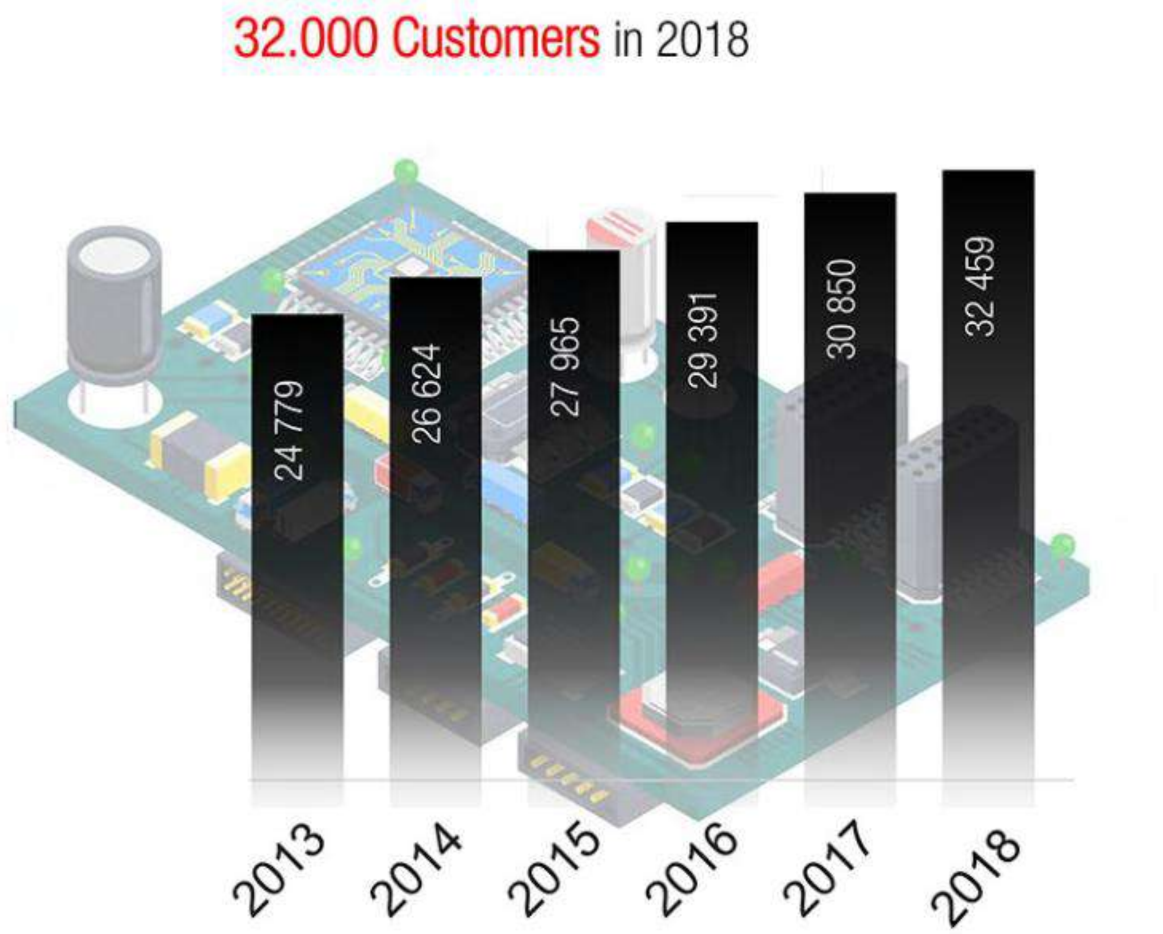
Paul LE NÉZET

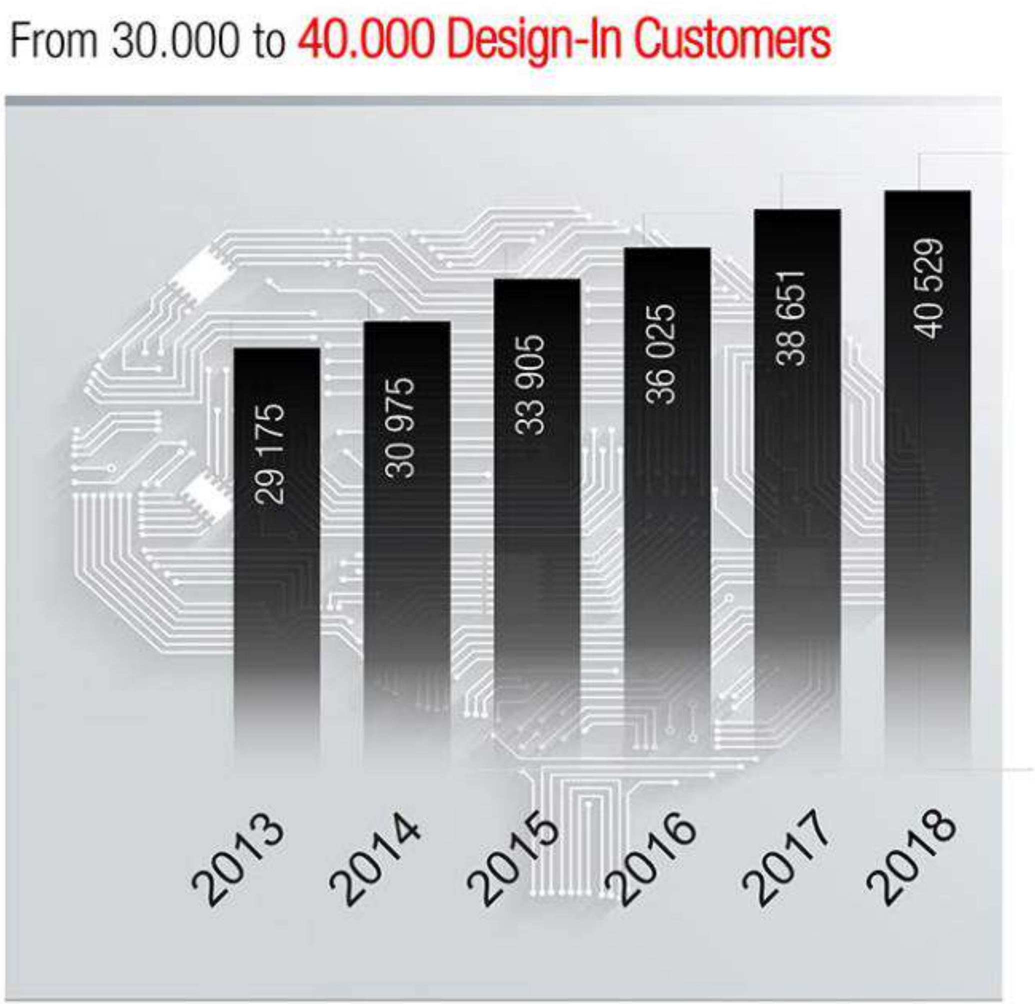


more than you expect

Introduction

Introduction





Introduction

Paul LE NEZET

Field Application Engineer eiSos

Christopher PAUL

Salesman eiSos

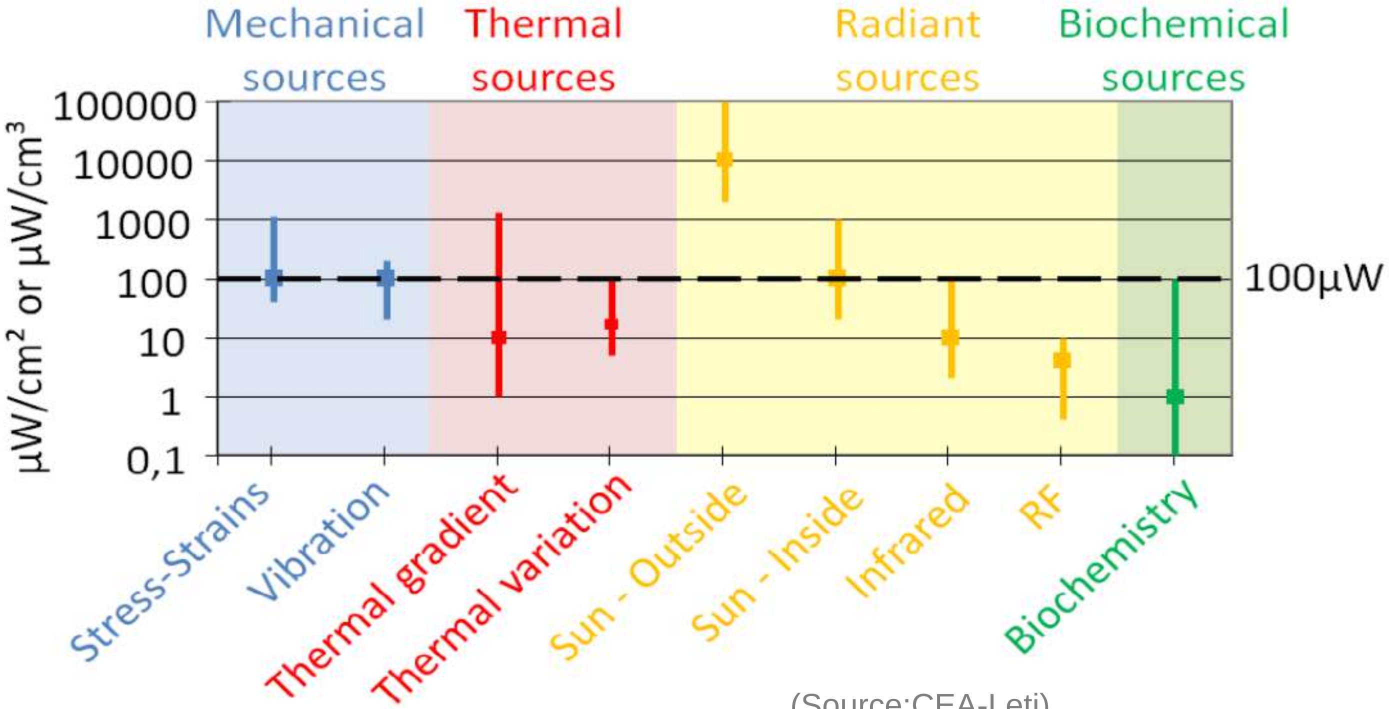
4 FAEs in France

20 Salesmen in France

Where to find “Free Energy“

- **Typical energy harvester output power**
  - → RF: 0.1µW/cm²
  - → Vibration: 1mW/cm²
  - → Thermal: 10mW/cm²
  - → Photovoltaic: 100mW/cm²

- **Typical energy harvester voltages**
  - → RF: 0.01mV
  - → Vibration: 0.1 ~ 0.4 V
  - → Thermal: 0.02 ~ 1.0 V
  - → Photovoltaic: 0.5 ~ 0.7 V typ/cell



(Source:CEA-Leti)

Considerations for harvesting energy

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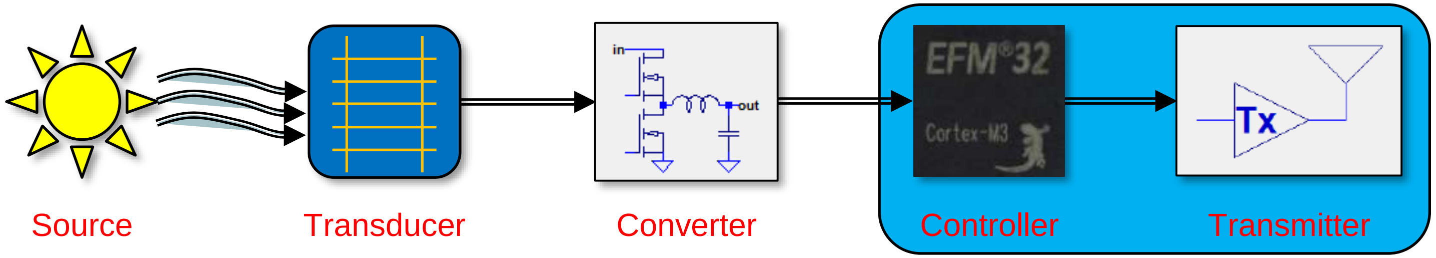
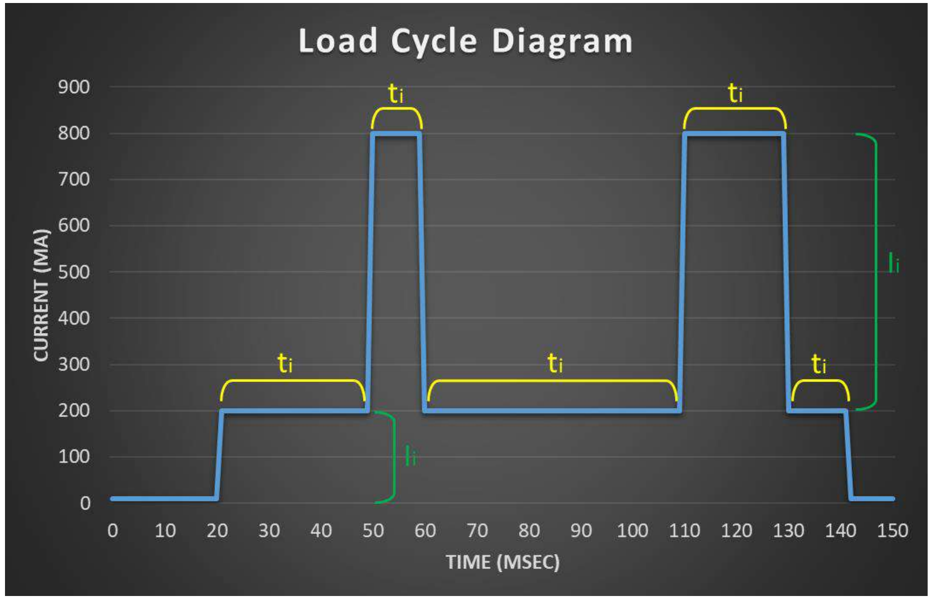


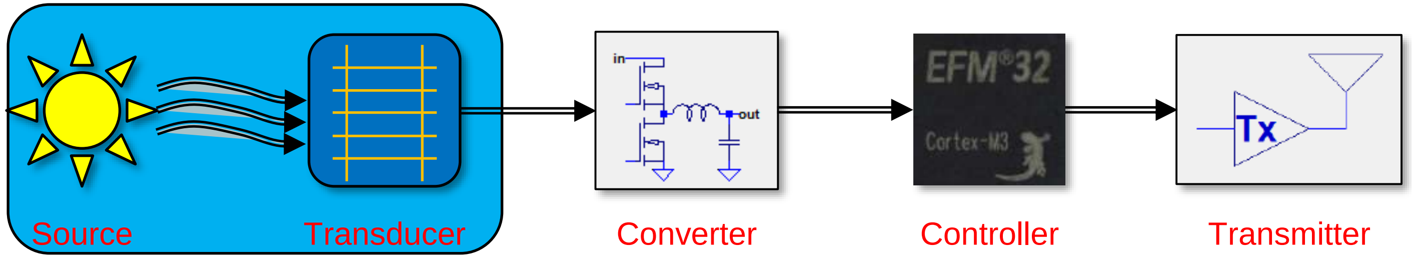
Step 1: Your needs

- Calculate the total energy
- Check peak demands

$$E\ total = \int P(t) * dt = \sum_i Pi * ti = \sum_i Ii\ * Vi\ * ti$$



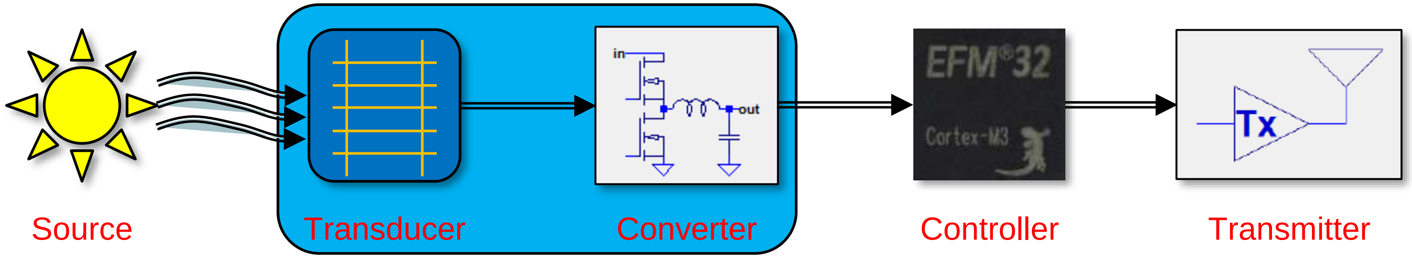
Considerations for harvesting energy



Step 2: Watch out your capabilities

- Consider the source characteristics
- Think about the stability over time
- What about the energy earning distribution over time, in average, …

Considerations for harvesting energy



Step 3: try to match both

- Choose the right transducer
- Match it with the right voltage converter
- If needed consider an energy storage

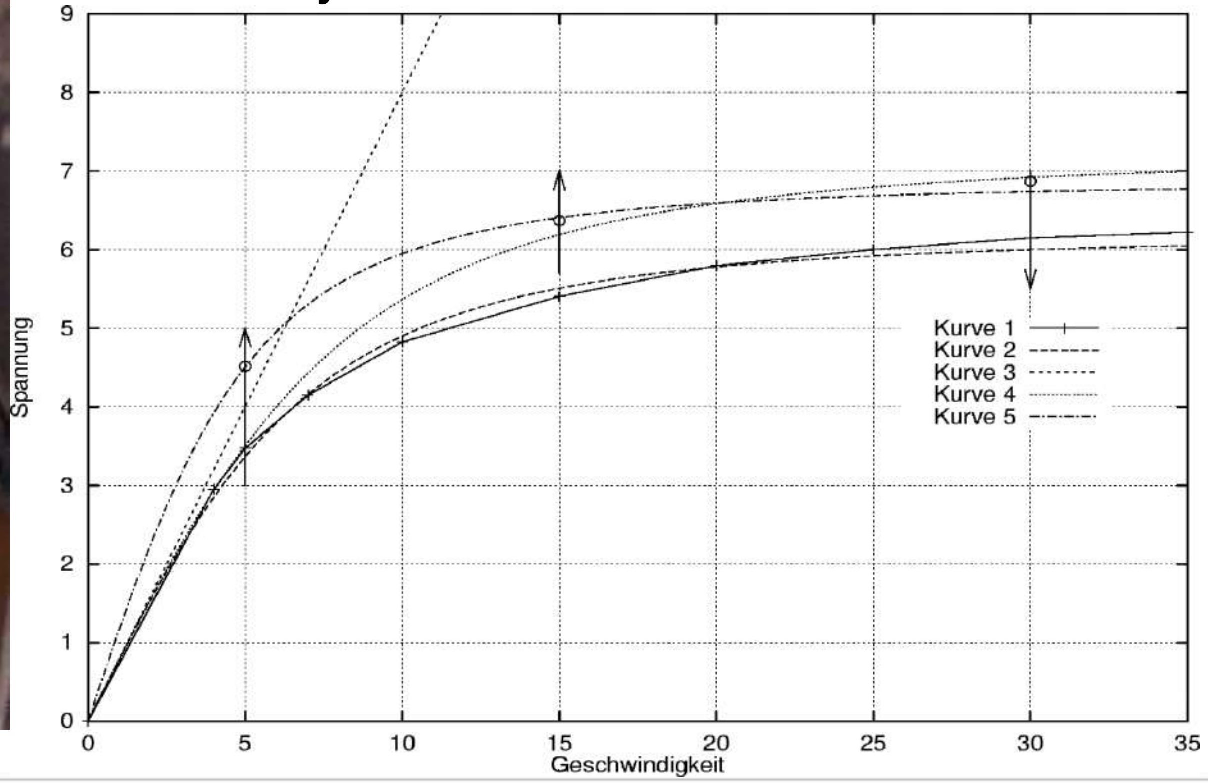
Typical transducers

Average Power: 3W

Downhill Peak Power: 4W

Output Voltage: 6V @ 12Ω Load

Felt Efficiency: <10%



Typical transducers

EM-1D-09 — Vibration Generator

Generator Data		
Dimensions (L x W x H)	60x24x22	mm
Volume	32	cm^3
Mass	42	g
Inner Resistant	430	Ω
Resonant Frequency	14.2	Hz
Power Output (0.5*g continous*)	3.6	mW
Power Density	0.11	mW/cm^3
Specific Power	85.7	mW/kg
Frequency Range of 50% Power	12.4 - 16	Hz

Generator Code: 151001200019

EM-1D-10 — Vibration and Push-Button Generator

Generator Data		
Dimensions (L x W x H)	60x24x22	mm
Volume	32	cm^3
Mass	46.5	g
Inner Resistant	430	Ω
Resonant Frequency	47	Hz
Power Output (0.5*g continous*)	30	mW
Power Density	0.96	mW/cm^3
Specific Power	660	mW/kg
Frequency Range of 50% Power	42 - 48	Hz
Energy Output (1x Push Button)	1.5	mJ

Generator Code: 151001200018

Source: www.pmdm.de

EnOcean

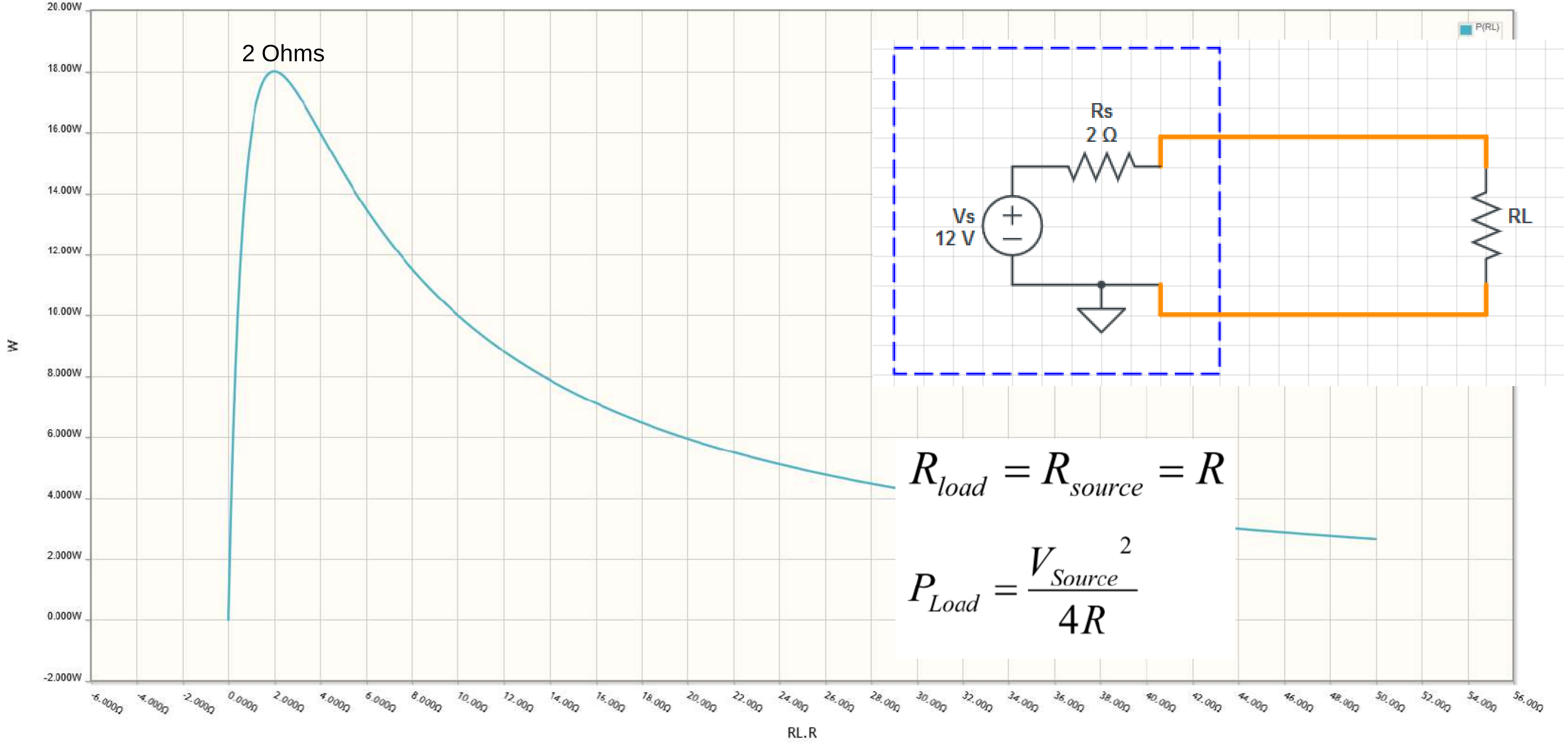
Per Click 30µC

6.38V @ 4.7µF

Source: www.enocean-alliance.org

Matching between transducer and load

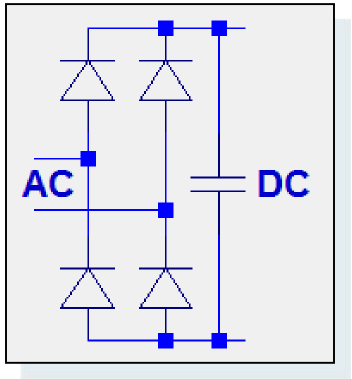
Maximum Power Transfert Point – Resistive system



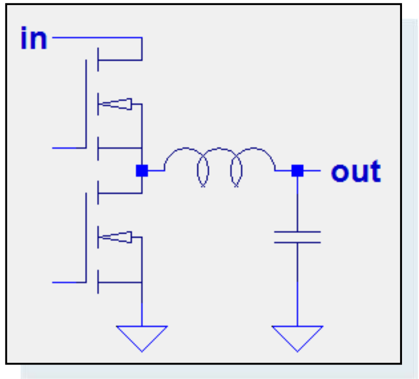
$$R_{load} = R_{source} = R$$

$$P_{Load} = \frac{V_{Source}^{2}}{4R}$$

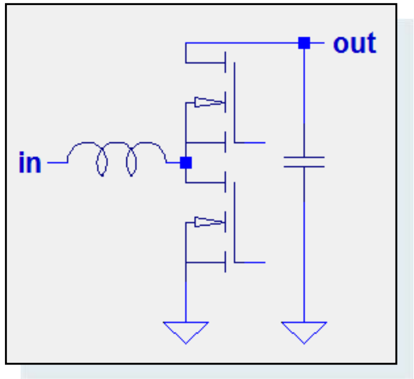
Matching between transducer and load



AC/DC by Rectifier

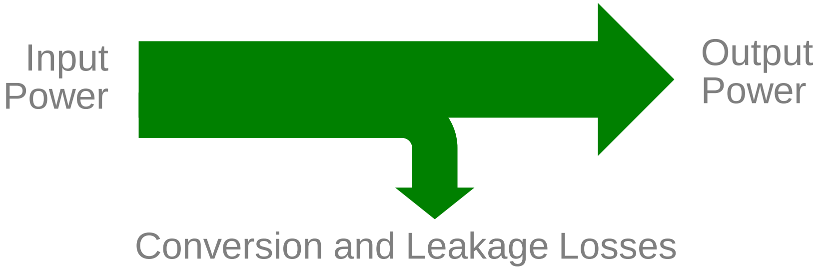


Step Down by Buck

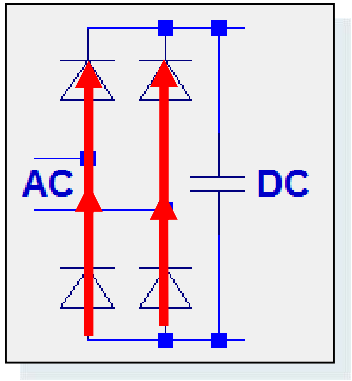


Step Up by Boost

Every Conversion and Leakage causes Losses



Matching between transducer and load



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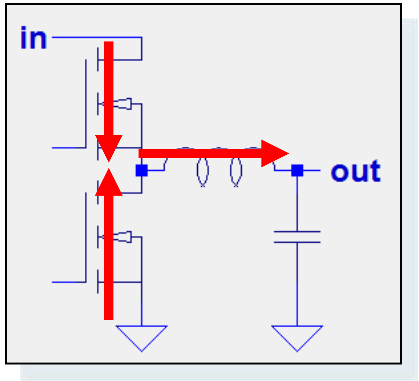
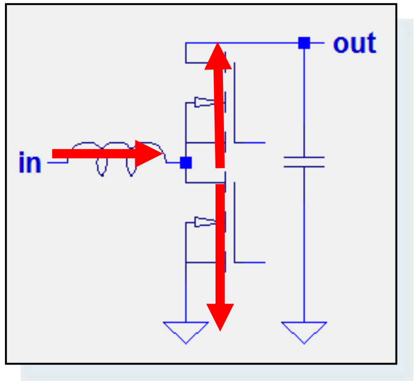


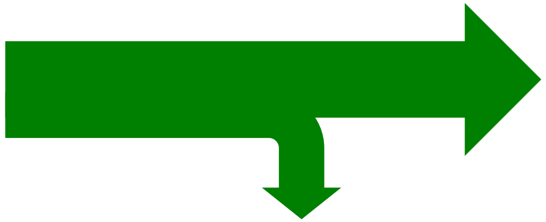
Step Down by Buck



Step Up by Boost

Every Conversion and Leakage causes Losses

Input Power

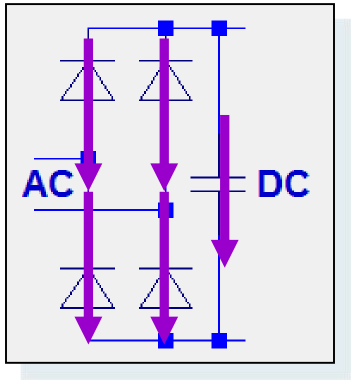


Output Power

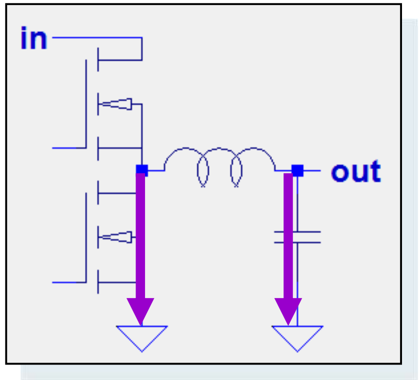
Conversion and Leakage Losses

- Losses due voltage drops

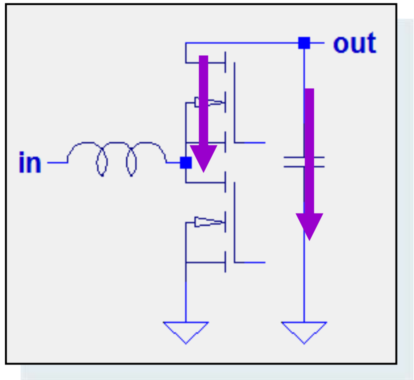
Matching between transducer and load



AC/DC by Rectifier

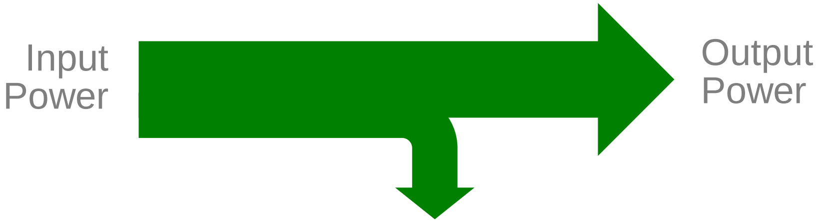


Step Down by Buck



Step Up by Boost

Every Conversion and Leakage causes Losses



Conversion and Leakage Losses

- Losses due voltage drops
- Losses due leakage

Losses in an inductor

$$Ptotal = Pcore + Pcopper$$

Core losses

- Hysteresis losses
- Eddy current losses

Copper losses

- DC losses – depending on DCR
- AC-losses – dep. on winding structure

  → Skin-Effect

  → Proximity-Effect

The target is to reduce as much as possible this losses when we select an inductor

Losses in an inductor

$P_{TOTAL} = P_{COPPER} + P_{CORE}$

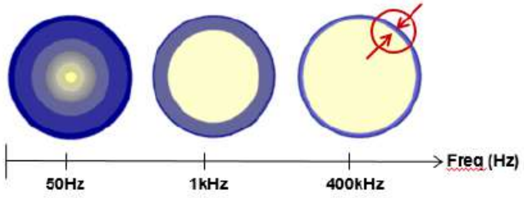
Copper Losses = P_{DC_Copper} + P_{AC_Copper}

$P_{DC} = R_{DC} * I^2$

Lower RDC => Lower copper losses

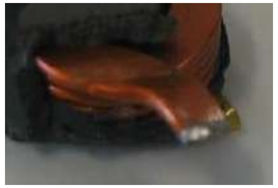
Bigger copper wire

P_{AC} caused by Skin and Proximity and effect



The AC resistance increase with the frequency as the current doesn't circulate on all the surface.

⇒ Use wire with bigger circumference like flat wire or Litz wire



Impact of the changes

Bigger wire ↗ lower Copper losses ↘ Bigger Size ↗

Reduce Number of turn ↘ lower Copper losses ↘ higher core losses ↗

Losses in an inductor

$$P_{TOTAL} = P_{COPPER} + P_{CORE}$$

Core Losses

$$P_{core} = K \cdot f^{a} \cdot B^{b}$$

F : switching frequency

K an **b** : depend of the Core, material, shape and size

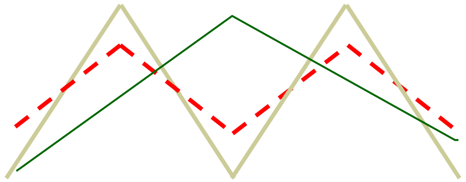
(Bigger the core lower is K)

B : depend on the ripple current

To reduce the core losses :

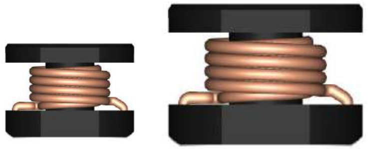
Reduce the ripple (Increase L)

Reduce the switching frequency



Increase the size of the core

Change material



Impact of the changes

Bigger core ↑ lower Core losses ↘ Bigger Size ↑

Increase Number of turn ↑ lower Core losses ↘ higher copper losses ↑

REDEXPERT


Start
Würth Elektronik Group
alain
English
more than you expect
Inductors REDEXPERT
Buck Converter
PARAMETERS
EDIT
Input
12.0 V
12.0-12.0 V
Output
3.30 V
200 mA
Switch
300 kHz
Inductor
40 %
Single
Diode
0.30 V
DETAILS
DC
0.29
976 ns
106 µH
WE-TPC - 744042101
84.9 mA
242 mA
AC Losses
14.2 mW
DC Losses
46.8 mW
Total Losses
61.0 mW
Warming
11.9 K
Filters
Type = Single
84 items
Series
Order Code
Spec
Type
L
AC L...
DC L...
Total...
War...
Size
Length
Width
Height
Shiel...
WE-TPC 744042101 Single 100 µH 1.17 Ω 0.400 A 300 mA 14.2 mW 46.8 mW 61.0 mW 11.9 K 4818 4.8 mm 4.8 mm 1.8 mm 125°C
WE-TPC 744043101 Single 100 µH 550 mΩ 0.510 A 290 mA 11.5 mW 22.0 mW 33.5 mW 9.04 K 4828 4.8 mm 4.8 mm 2.8 mm 125°C
WE-TPC 744052101 Single 100 µH 815 mΩ 0.350 A 420 mA 10.5 mW 32.6 mW 43.1 mW 15.0 K 5818 5.8 mm 5.8 mm 1.8 mm 125°C
WE-TPC 744053101 Single 100 µH 400 mΩ 0.450 A 450 mA 8.66 mW 16.0 mW 24.7 mW 11.2 K 5828 5.8 mm 5.8 mm 2.8 mm 125°C
WE-TPC 744062101 Single 100 µH 440 mΩ 0.550 A 470 mA 7.38 mW 17.6 mW 25.0 mW 7.54 K 6823 6.8 mm 6.8 mm 2.3 mm 125°C
WE-TPC 744071101 Single 100 µH 270 mΩ 1.00 A 900 mA 8.46 mW 10.8 mW 19.3 mW 4.53 K 8043 8.0 mm 8.0 mm 4.3 mm 125°C
WE-TPC 744065820 Single 82.0 µH 323 mΩ 1.10 A 1.00 A 8.78 mW 12.9 mW 21.7 mW 2.75 K 1028 10 mm 10 mm 2.8 mm 125°C
744042101
WE-TPC · Single
100 µH · 1.17 Ω
0.400 A · 300 mA
Share
Free Samples
Tidy Up
Inductance / Current
Inductance (µH)
Current (A)
Temperature Rise / Current
Temperature Rise (K)
Current (A)

Energy Harvesting Kit

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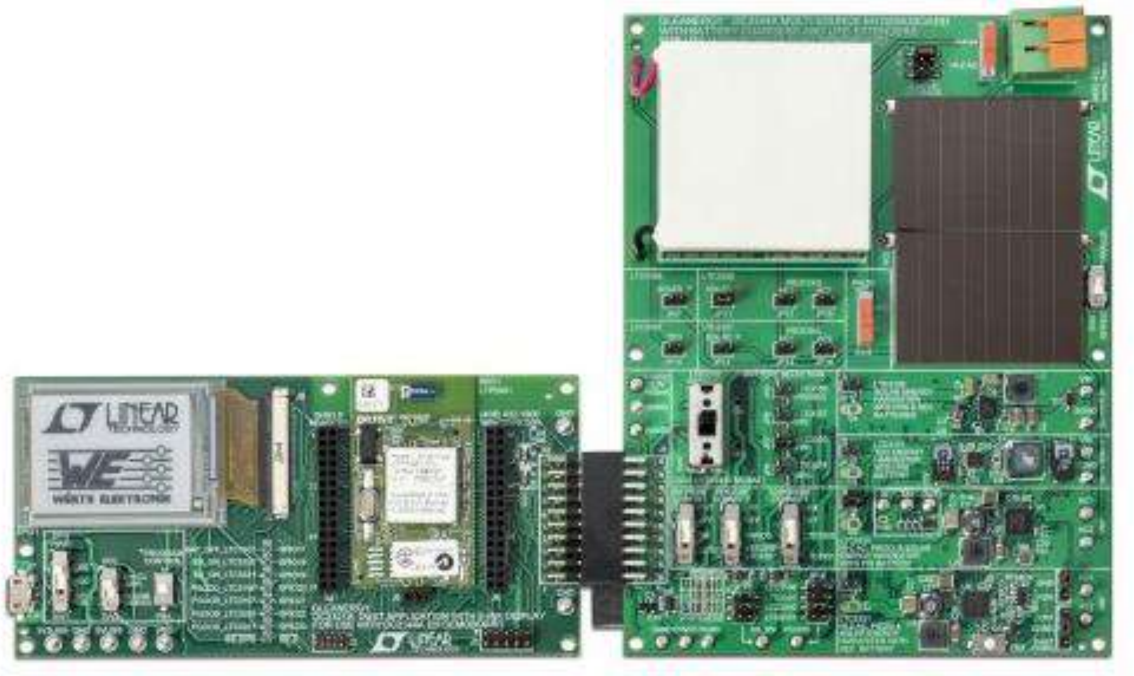
- https://www.we-online.com/.../energy_harvesting/gleanergy/gleanergy.php



Energy Harvesting Kit – Demoboard DC2344A

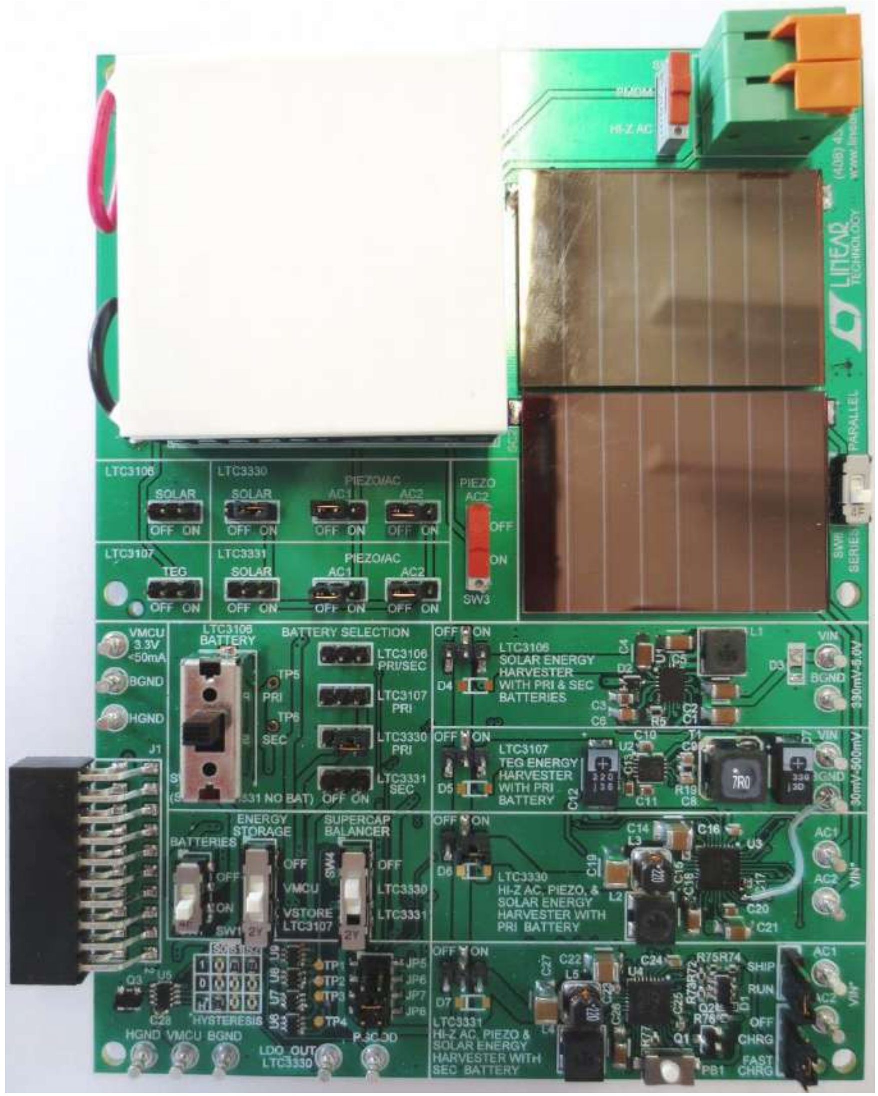
Featuring:

LTC3106 - Solar Harvesting
- Battery Lithium
- Li-Ion Rechargeable

LTC3107 - TEG Harvesting
- Battery Lithium

LTC3330 - Piezo Harvesting
- Solar Harvesting
- Battery Lithium
- Supercap Balancer

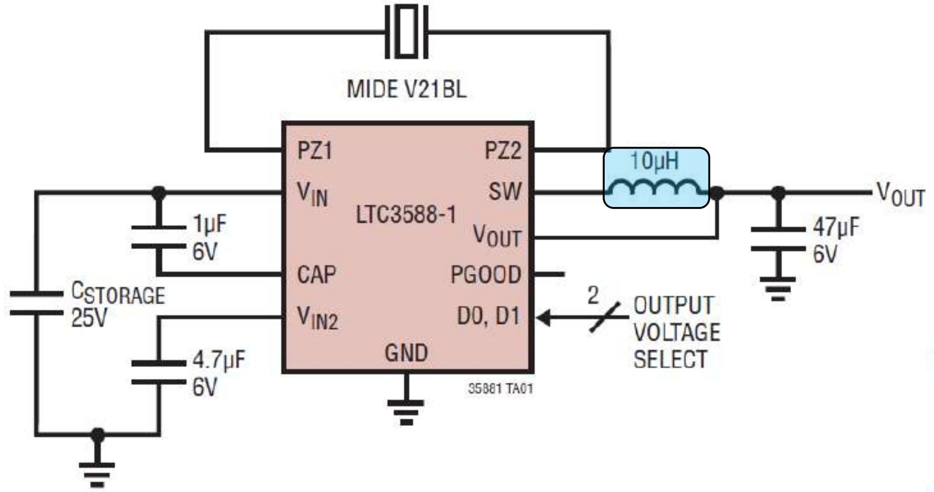
LTC3331 - Piezo Harvesting
- Solar Harvesting
- Li-Ion Rechargeable
- Supercap Balancer



Energy Harvesting Kit – Demoboard DC2344A

TYPICAL APPLICATION

100mA Piezoelectric Energy Harvesting Power Supply

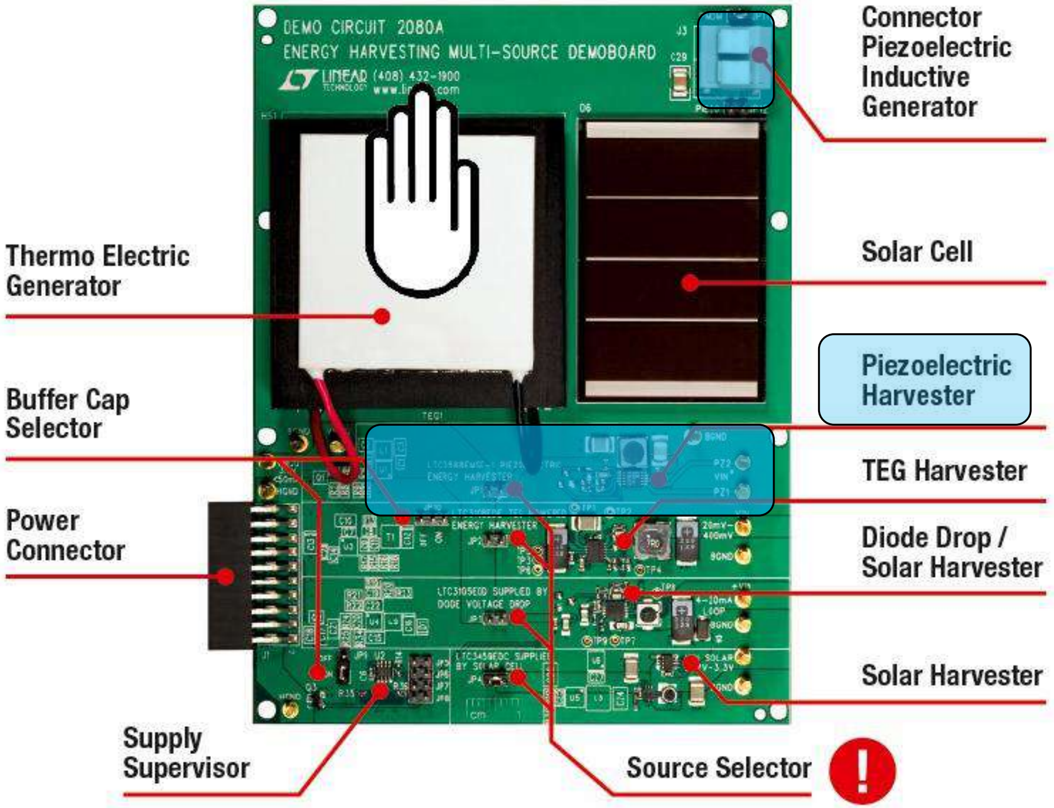


Extremely flat power inductor

High current capability

Magnetically shielded which

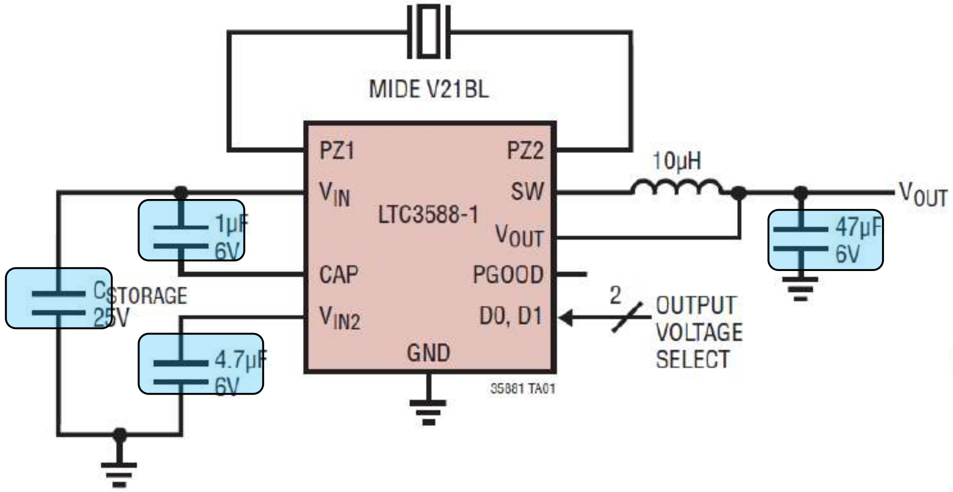
results in a low leakage field



Energy Harvesting Kit – Demoboard DC2344A

TYPICAL APPLICATION

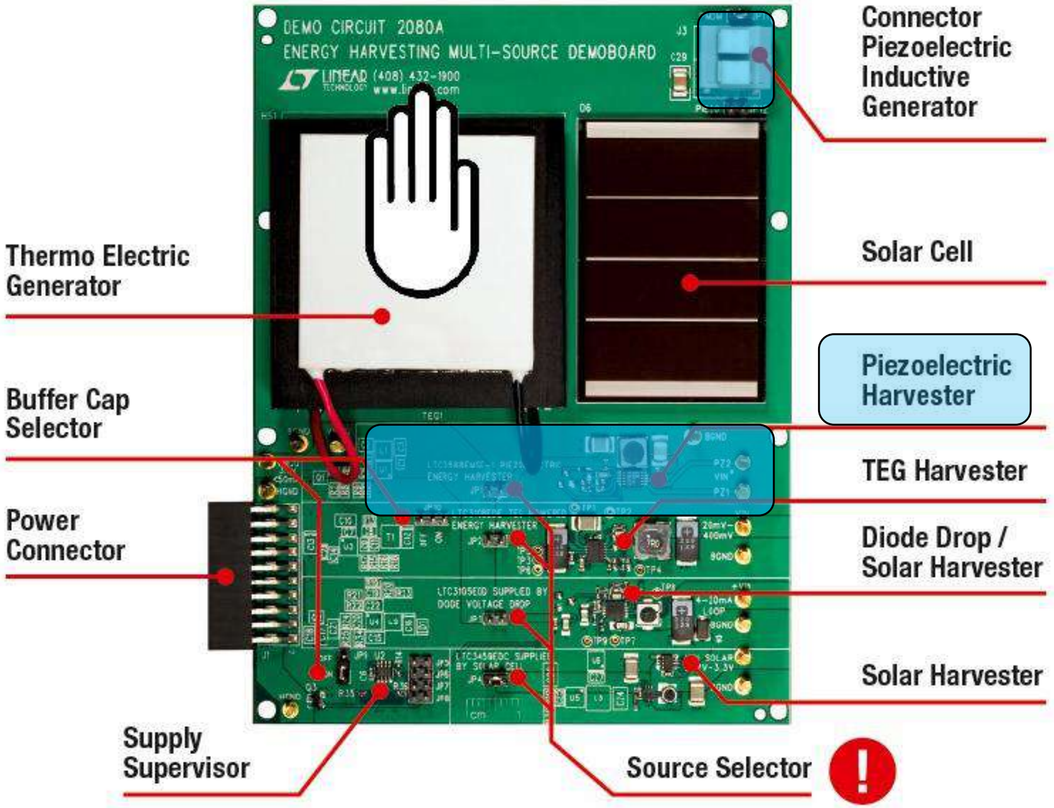
100mA Piezoelectric Energy Harvesting Power Supply



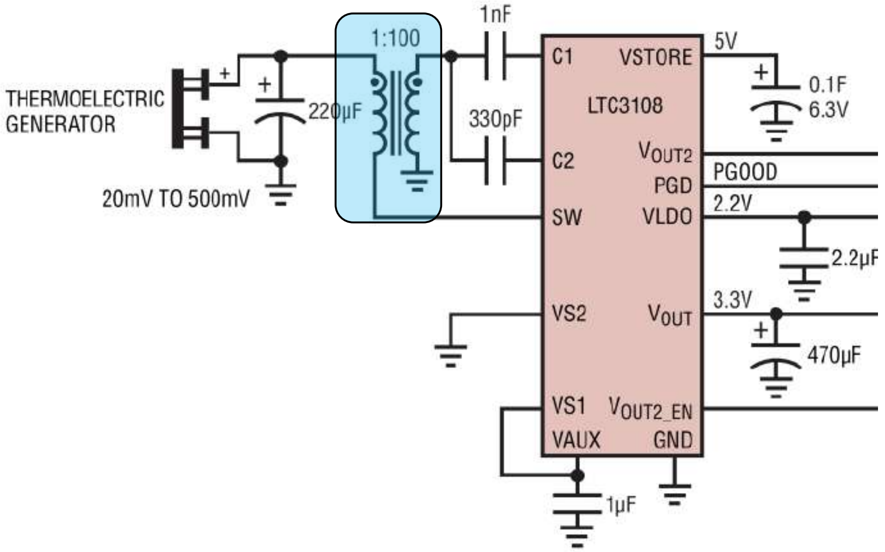
Multilayer Ceramic

Chip Capacitor

X7R , X5R



Energy Harvesting Kit – Demoboard DC2344A

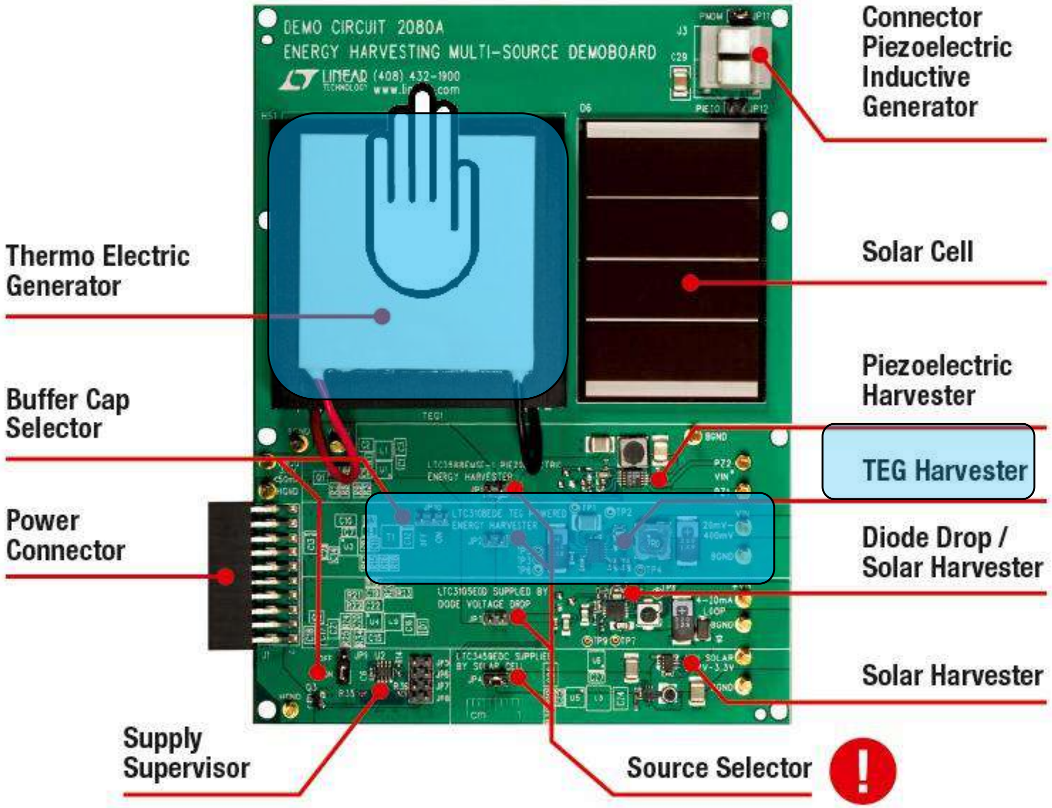


Low profile: 4 mm

Small footprint 6 x 6 mm

Very low secondary RDC

Multiple options of turn ratios available



What is behind the WE-EHP transformer?

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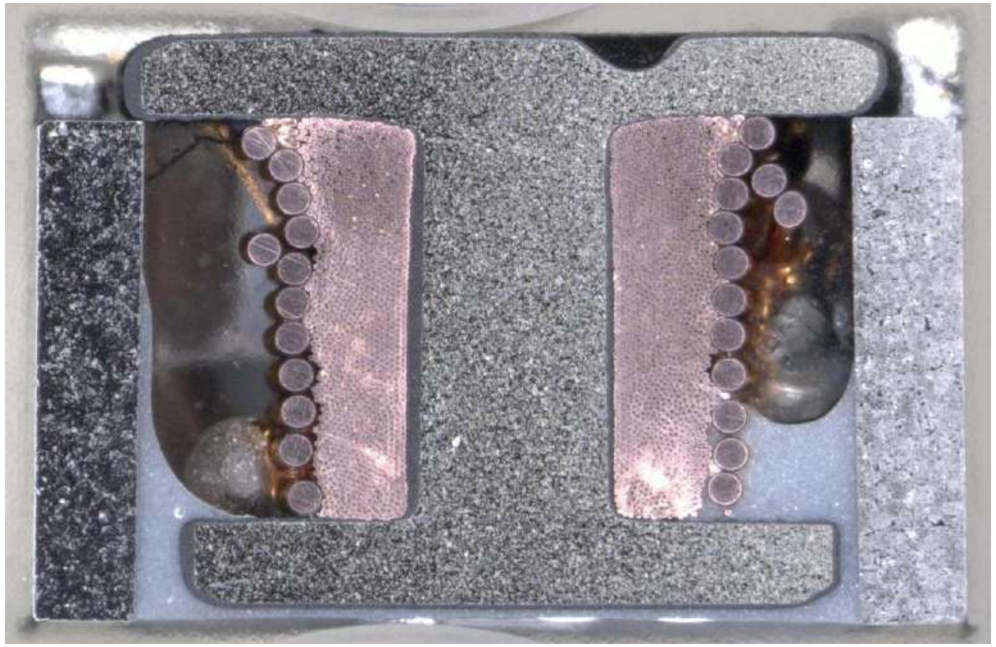
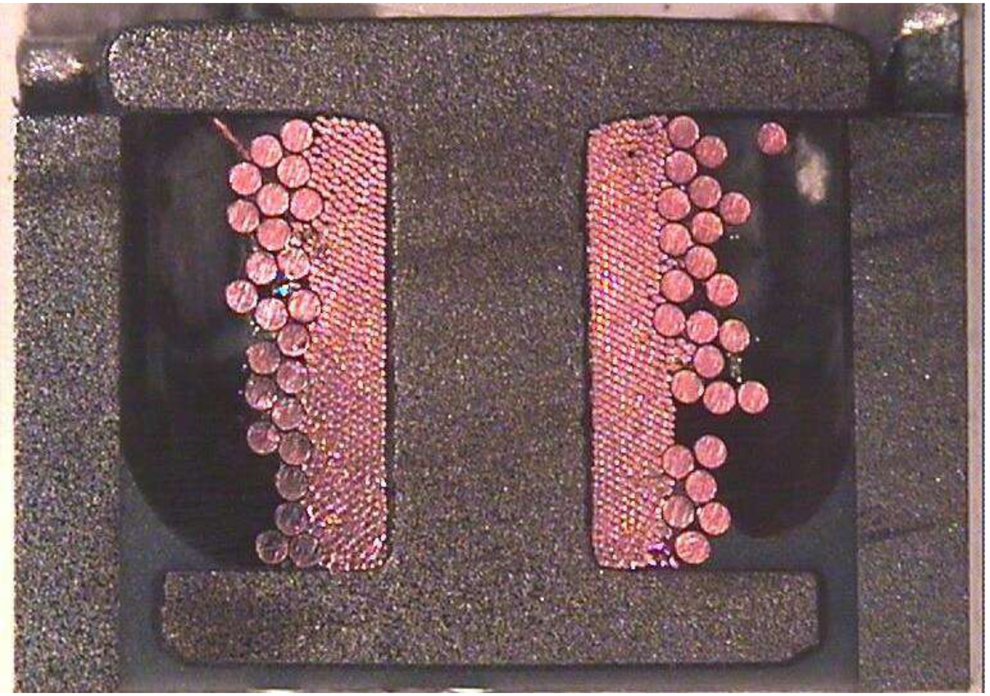
- winding style





What is behind the WE-EHP transformer?

WE-EHPI
Energy Harvesting Power Inductor

Characteristics

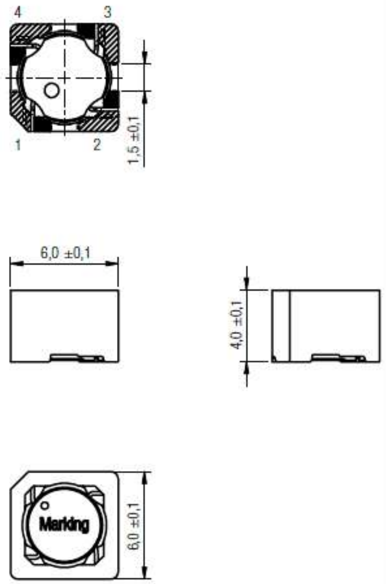
- Low profile: 4 mm
- Small footprint 6 x 6 mm
- Very low secondary R_{DC}
- Different turn ratios available
- Separated welding/soldering pad for a high reliable component
- Optimized, high reliable winding style

Applications

- Wireless fire, alarm, gas and metering remote sensors driven by environmental energies based on energy harvesting voltage transformers like LTC3108/LTC3109
- Sensors with predictive battery replacements in applications which are difficult to access
- Energy self-sufficient supply using subsequent installed sensors for energy harvesting

QR-Code

Dimensions (in mm)

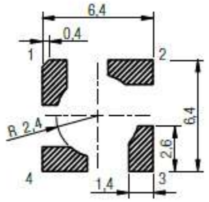


Electrical properties

Order Code	L_1 ±20% (µH)	L_2 ±20% (µH)	n	I_{R1} (A)	I_{sat1} (A)	R_{DC1} (Ω)	R_{DC2} (Ω)
744 885 400 70	7.5	75000	1:100	1.9	1.3	0.085	205
744 885 401 20	13.0	33000	1:50	1.7	1.0	0.090	135
744 885 402 50	25.0	10000	1:20	1.5	0.7	0.200	42

Schematic

Land pattern (in mm)



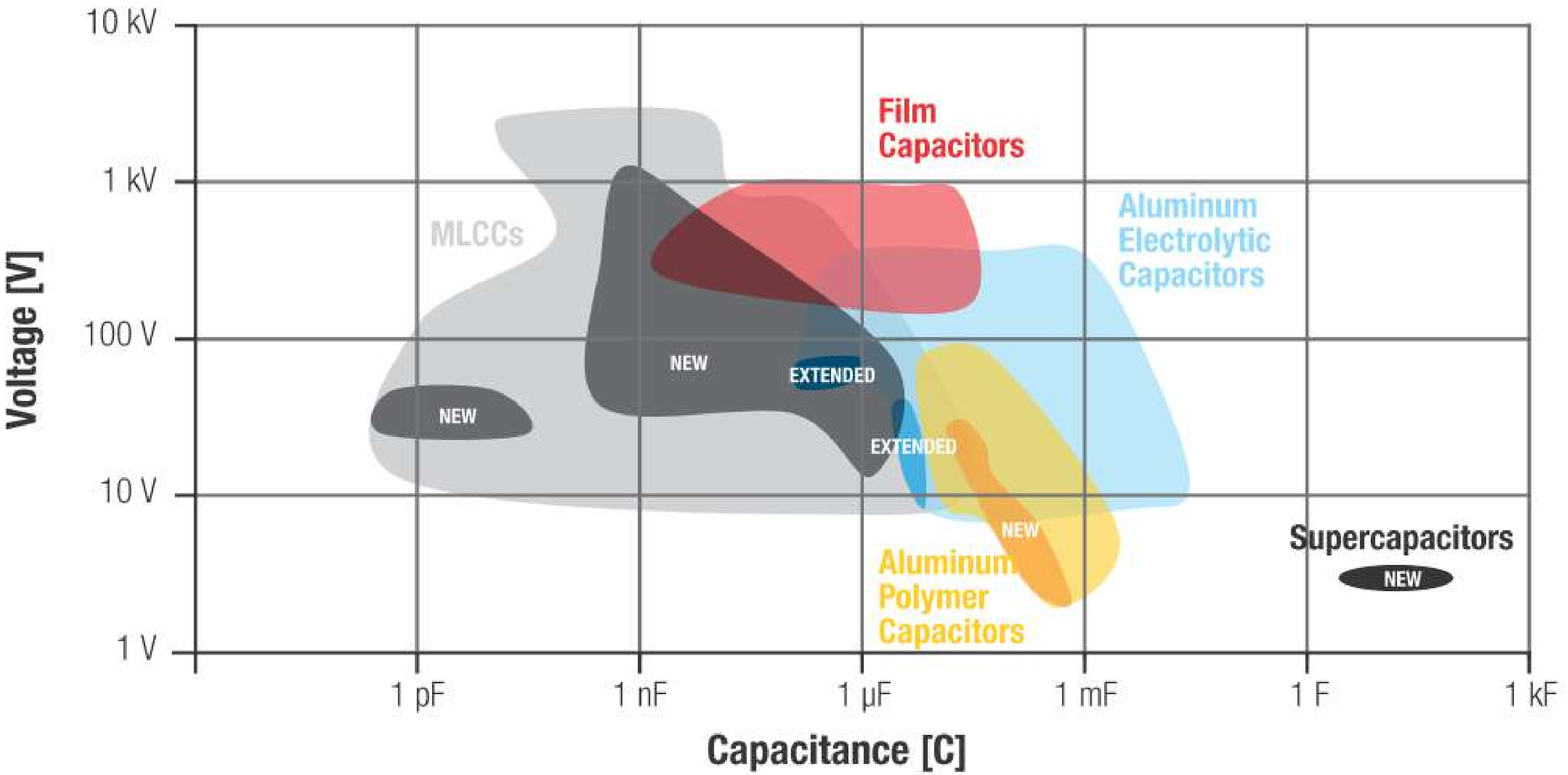
Transformer designed on EP7 cores are available on request – Order code: 760370096, 760370097, 760370098

During design stage of this series, we used S11100032, S11100033 & S11100034.
With our standard series we have replaced these order codes.

Supercapacitor – WCAP STSC

Radial THT

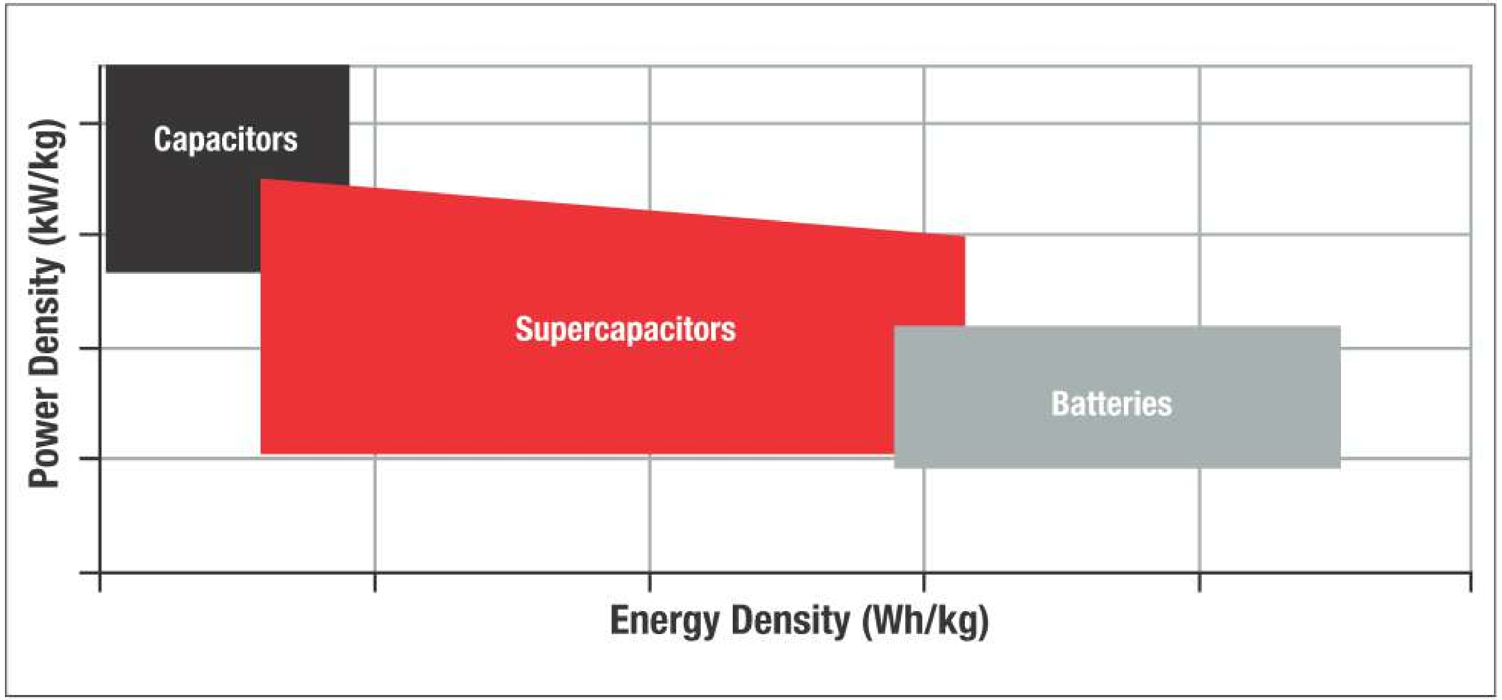
Technical Data:		
Order Code	C (F)	V_R (V (DC))
850617030001	3	2.7
850617021001	5	
850617021002	7	
850617021004	10	
850617021005	15	
850617022001	25	
850617022002	50	



Supercapacitor – WCAP STSC

Radial THT

Technical Data:		
Order Code	C (F)	V_R (V (DC))
850617030001	3	2.7
850617021001	5	
850617021002	7	
850617021004	10	
850617021005	15	
850617022001	25	
850617022002	50	



Where is it useful?

- Where line power is unavailable or costly
- Where batteries are costly or difficult to replace
- Where energy is needed only when ambient energy is present

Asset Tracking/Monitoring

Building Security, Lighting & Climate Control

Plant Automation

Remote Monitoring

TPMS

Source: LTC - Sam Nork – Energy Harvesting Presentation

Where is it useful?

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Source: http://www.joaolammoglia.com/concept/1/aire-concept/

See you soon

Nous n'avons pas répondu à toutes vos questions durant la session de questions – réponses ? Envoyez-nous un Email à eisos-france@we-online.com ou à votre contact habituel chez Würth Elektronik et nous prendrons contact avec vous au plus vite.

Des webinaires disponible sur notre chaine Youtube (www.we-online.com/youtube)

Pensez à vous abonner à notre page LinkedIn pour plus de nouvelles www.we-online.com/linkedin/france


THANK YOU