Conducted EMI

WURTH ELECTRONICS MIDCOM INC.

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Retlif Labs

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Topics

1. EMI/EMC – General Information – Why need EMI reduction?
2. Materials – Frequencies for Effectiveness
3. Shielded and Un-shield comparison
4. Inductors vs. Ferrites
5. Common Mode and Differential Mode
6. Conducted EMI emission analysis
7. Information on Transformers
Switching Regulator Topologies

**Switch mode power supply**

- **Non-Isolated**
  - Step-down converter
    - WE-PD
  - Step-up converter
    - WE-PD
  - SEPIC converter
    - 2 x WE-PD or 1 x WE-DD

- **Isolated**
  - Flyback converter
    - WE-PoE
    - WE-FLEX with airgap
      - WE-PoE
      - WE-FLEX w/o airgap + WE-PD
  - Forward converter
    - WE-FLEX w/o airgap + WE-PD
  - Push-Pull converter

**Insulation Voltage**

- **WE-PoE**
  - 0-100V
  - 0-500V
  - >=1500V
## Switching Regulator Topologies

<table>
<thead>
<tr>
<th>Switching Regulator Topology</th>
<th>Inductive Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step-down-converter (Buck-Converter)</td>
<td>Storage inductor =&gt; WE-SI/FI or WE-HC/- or WE-PD-Series</td>
</tr>
<tr>
<td>Step-up-Converter (Boost-Converter)</td>
<td>Storage inductor =&gt; WE-SI/FI or WE-HC/- or WE-PD-Series</td>
</tr>
<tr>
<td>SEPIC Single ended primary inductance converter</td>
<td>Coupled storage inductor with two windings or two identical storage inductors =&gt; WE-DD or WE-FLEX (with airgap !)</td>
</tr>
<tr>
<td>CUK converter</td>
<td></td>
</tr>
<tr>
<td>Flyback-Converter</td>
<td>Flyback-transformer =&gt; WE-FLEX (gap !)</td>
</tr>
<tr>
<td>Forward-Converter</td>
<td>Transformer and storage inductor =&gt; WE-FLEX (no gap !)</td>
</tr>
<tr>
<td>Push-pull Converter</td>
<td>Transformer and storage inductor =&gt; WE-FLEX (no gap !)</td>
</tr>
</tbody>
</table>
Inductor Selector Guide
Interference - Transmitter / Receiver

- BUS
- SYSTEM
- Source
- Power supply
- Ground connections
- Field
- I/O Signal
Interference - Frequency Range for EMI Tests

- VDE - Conducted
- FCC - Conducted
- MIL-STD - Conducted
- VDE - Radiated
- FCC - Radiated
- MIL-STD - Radiated

Frequency:
- 150KHz
- 30MHz
- 1GHz
Interference Characteristics

Symmetrical
- Conducted noise
  - Powder-, rod core chokes

Asymmetrical
- Coupled noise
  - CM- chokes

Field
- Radiated noise
  - EMI ferrites, shielding

\[ f \text{ (MHz)} \]

Graph showing the frequency range for different types of interference characteristics.
Comparison of Core Materials: Inductive behavior

$X_L (Fe)$

$X_L (MnZn)$

$X_L (NiZn)$

Impedanz

Frequenz (MHz)

0,01 0,1 1 10 100 1000
EMI: Conducted Emission Measurement

- Power supply V 1.0

Buck Converter ST L4960/2.5A/fs 85-115KHz
EMI: Conducted Emission Measurement

- Power supply V 1.1

![Graph showing conducted emissions measurement](image)

![PCB with annotations](image)

![Schematic diagram](image)
EMI: Be Aware:

- Select the right parts for your application
- Do not always look on cost

Very easy solution with a dramatic result!!!

Choke before  

or 

Choke after
EMI: Shielded vs. Unshielded Power Inductor
EMI: Shielded vs. Unshielded Power Inductor
EMI: Shielded vs. Unshielded Power Inductor

- Magnetic field

Shielded

Unshielded
What is the main different between a Inductor and EMC-Ferrite?

=> Application **Storage Choke**: (Inductor)
   Request: **lowest possible losses** at application frequency
   high Q-factor

=> Application as **absorber-filter**: (EMC Ferrite)
   Request: **highest losses possible** at application frequency range
   low Q-factor
Ferrite Material
Ferrite Inductors WE-CBF
Inductor vs. EMI-Ferrite:

Comparison Q-Factor: Ferrite vs. Inductor

\[ Q = \frac{X_L}{R_{Losses}} \]
Impedance increase vs. numbers of turns
Why CMC‘s instead of Chip Beads

Impact of DC-bias (pre-magnetization (saturation))

800Ω@100MHZ (0ADC)

420Ω@100MHZ (1.7ADC)

230Ω@100MHZ (3ADC)

742792515 (3A typ)
Impact of DC-Bias (pre-magnetization (saturation))
Common Mode Choke

- comparison common mode chokes CMB – CMB NiZn
Advantage of a Common Mode Choke

Filtering with two inductors or chip beads

Signal before filtering  after filtering

➢ Rise-time of the signal is affected, which could cause problems for fast data and signal lines

which occurs from the DC current the filtering performance is shortened.
➢ because of the pre-magnetization (saturation)
Advantage of a Common Mode Choke

Filtering with a Common Mode Choke

- no affect on the signal rise-time, because of magnetic field compensation
- no influence of the wanted signal (the two windings are magnetically coupled)
- no pre-magnetization (saturation) occurs from the DC current, because of magnetic coupling
- much better performance vs. two separate inductors or ferrites
Appearance of **differential noises** on the input line of a Flyback Converter

mostly high Caps >100uF; \( X_c = 1/(\omega \cdot C) \)

differential interference occurs mainly at **lower** frequencies
Common Mode Noise Example: Flyback Converter

Appearance of common mode noises on the input line of a Flyback Converter

mostly high Cap Values >100uF; \( X_c = 1/(\omega C) \)

common mode interference

differential interference

parasitic capacities; in the lower pF/nF (e.g. VCC layer to GND layer (coupling))

common mode interference occurs mainly at higher frequencies
Filtering Noise Example: Flyback Converter

Filtering the mains power line for common mode and differential mode

WE-VD  Cx  WE-LF SMD  2xCy  Cx  2xWE-UKW
C=0,1µF  L= 2x2.2mH  C=2,2nF  C=1nF  L= ca.5~10µH

Diagram:

- L1 (+)  L'1
- N (-)  N'
- PE (GND)  PE'
Common mode / Differential mode

The DIFFERENTIAL Mode Signal creates a Flux in opposite directions – Thereby canceling

The COMMON MODE signal does not cancel and an Inductive Impedance is created thereby acting as a filter
The DIFFERENTIAL Mode Signal creates a Flux in opposite directions – Thereby canceling
The operational current (diff. mode) is routed by all relevant conductors through the core
(e.g. +/- or L/N). That’s why the magnetic fields of these two conductors compensate each
other to zero => no influence on the wanted signal

The COMMON MODE signal does not cancel and an Inductive Impedance is created thereby
acting as a filter
The disturbance current flows on both wires in the same direction and generates a magnetic
field in the toroidal core => the choke is able to filter unwanted noises.
Unbalanced Current

- The operating current on both conductors is almost the same. When the difference between input and output current is too big, the common mode choke is no longer compensated and starts saturating very fast!
Common Mode Choke

sectional winding

bifilar winding

< advantage? >
Stray inductance: Bifilar / Sectional

**Sectional**

\[ L_S \sim 0,5 \ldots 2\% \times L_R \]

**Bifilar**

\[ L_S \sim 0,1 \ldots 1,0 \% \times L_R \]
Sectional winding:

For example: WE-SL2 744227S

Common Mode suppression

Differential Mode suppression is high!
Bifilar winding vs. Sectional winding

For example: WE-SL2 744227

Common Mode suppression

Differential Mode S-Type

Differential Mode suppression is low!
# Common mode chokes for SMD:

<table>
<thead>
<tr>
<th>Size [mm]</th>
<th>Impedance [Ω]</th>
<th>Current [A]</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>WE-CNSW</td>
<td>2.0 x 1.2 x 1.2, 3.2 x 1.6 x 1.9</td>
<td>130 – 910, 60 – 400</td>
<td>0.28 – 0.4, 0.20 – 0.37</td>
</tr>
<tr>
<td>WE-SL</td>
<td>12.7 x 10.5 x 5.75</td>
<td>1100 – 14400</td>
<td>0.20 – 2.70</td>
</tr>
<tr>
<td>WE-SL 1</td>
<td>6.5 x 3.6 x 1.65</td>
<td>300 – 2000</td>
<td>0.30</td>
</tr>
<tr>
<td>744212xxx</td>
<td>6.5 x 3.6 x 1.65</td>
<td>300 – 2000</td>
<td>0.30</td>
</tr>
<tr>
<td>WE-SL 2</td>
<td>9.2 x 6.0 x 5.0</td>
<td>1000 – 20000</td>
<td>0.40 – 1.60</td>
</tr>
<tr>
<td>WE-SL 3</td>
<td>9.2 x 6.6 x 2.5</td>
<td>1250 – 5000</td>
<td>0.50 – 0.70</td>
</tr>
<tr>
<td>744252/253xxx</td>
<td>9.2 x 6.6 x 2.5</td>
<td>1250 – 5000</td>
<td>0.50 – 0.70</td>
</tr>
<tr>
<td>WE-SL 5</td>
<td>10.0 x 8.2 x 6.5</td>
<td>290 – 13000</td>
<td>0.35 – 2.50</td>
</tr>
<tr>
<td>744272xxx</td>
<td>10.0 x 8.2 x 6.5</td>
<td>290 – 13000</td>
<td>0.35 – 2.50</td>
</tr>
</tbody>
</table>
Common Mode Choke

- different designs

WE-SL2 744226S
sectional winding

WE-SL2 7442276
bifilar winding
CMC - USB 2.0 Filtering for Common Mode Noise
 Too much differential mode impedance distorts the USB 2.0 eye pattern
How Much Inductance is Needed?

before

only changed one component

30mH!
Common Mode Choke (Sectional)

- When do we offer a sectional winding?
  - power supply: "high" voltage application
  - signal: low and high speed signal
  - only solution to guarantee distances between the two winding according to IEC60938 or UL1283
  - max. voltage application: 250 VAC / DC
  - high leakage inductor
  - two products in one (preferred for power supplies)
  - max. voltage: print in data sheet
Common Mode Choke (Bifilar)

- data signal application

  bifilar → low leakage inductor

- power supply: low voltage application
- signal: only low speed signal

→ low voltage application
(42 VAC / 80V DC)
Common Mode Choke

- comparison Common Mode to Single Choke

<table>
<thead>
<tr>
<th></th>
<th>current compensated or common mode choke</th>
<th>single choke</th>
</tr>
</thead>
<tbody>
<tr>
<td>common mode impedance</td>
<td>high</td>
<td>low to medium</td>
</tr>
<tr>
<td>differential mode impedance</td>
<td>low</td>
<td>medium</td>
</tr>
<tr>
<td>dependency of impedance from load current</td>
<td>independent</td>
<td>depends on “core“</td>
</tr>
<tr>
<td>attenuation of used signal</td>
<td>low</td>
<td>high</td>
</tr>
</tbody>
</table>
What Impedance is Needed?
Conducted Emissions Example – Test and Compare

- Chip Bead
- Differential Choke
- Bifilar Wound Common Mode Choke
- Sector Wound Common Mode Choke
Conducted Emissions Example - Test Setup

a) no load
b) 1.5A load
300KHz fsw.
Conducted Emissions Example – Demo Board

FCC Class B limit
Isolates DUT (device under test) from Power Source (typically mains) Noise

- Provide characteristic Impedance to DUT (50ohms in this case)
- Path for Conducted noise from DUT to Spectrum Analyzer

Conducted Emissions Example - LISN

Line Impedance Stabilization Network (LISN)

The 1 µF in combination with the 50 µH inductor is the filter that isolates the mains from the EUT. The 50 µH inductor isolates the noise generated by the EUT from the mains. The 0.1 µF couples the noise generated by the EUT to the EMC analyzer or receiver. At frequencies above 150 kHz, the EUT signals are presented with a 50-Ω impedance.
Conducted Emissions Example – Electrical Load
Conducted Emissions Example – Test Board

- DC/DC Converter
- Input Voltage 20V-25V
- Output Voltage 12V/6.25A
- Fsw: 300KHz

Test condition:
- no load
- max. load 1.5A
Conducted Emissions Example – No Filter

FCC Class B limit
Conducted Emissions Example – Chip Bead

Chip Bead 530? / 3A
Conducted Emissions Example – Chip Bead Results

Chip Bead 530? / 3A

no load >

load 1.5A>
Conducted Emissions Example – Chip Bead

Chip Bead 530? / 3A
Conducted Emissions Example – Differential Choke

Differential Line Choke 220uH
Conducted Emissions Example – Bifilar CMC

CMC 4.7mH Bifilar Winding
Conducted Emissions Example – Bifilar CMC

<table>
<thead>
<tr>
<th>Artikel-Nr.</th>
<th>Induktivität (µH)</th>
<th>R_{DC} (Ω)</th>
<th>I_{N} (mA)</th>
<th>Impedanz max. (Ω)</th>
</tr>
</thead>
<tbody>
<tr>
<td>744272121</td>
<td>2 x 120</td>
<td>0,025</td>
<td>2500</td>
<td>400</td>
</tr>
<tr>
<td>744272221</td>
<td>2 x 220</td>
<td>0,032</td>
<td>2200</td>
<td>760</td>
</tr>
<tr>
<td>744272251</td>
<td>2 x 250</td>
<td>0,035</td>
<td>2000</td>
<td>970</td>
</tr>
<tr>
<td>744272471</td>
<td>2 x 470</td>
<td>0,066</td>
<td>1600</td>
<td>1750</td>
</tr>
<tr>
<td>744272102</td>
<td>2 x 1600</td>
<td>0,180</td>
<td>950</td>
<td>3600</td>
</tr>
<tr>
<td>744272222</td>
<td>2 x 2200</td>
<td>0,300</td>
<td>750</td>
<td>7500</td>
</tr>
<tr>
<td>744272332</td>
<td>2 x 3200</td>
<td>0,560</td>
<td>650</td>
<td>5900</td>
</tr>
<tr>
<td>744272392</td>
<td>2 x 3500</td>
<td>0,540</td>
<td>520</td>
<td>5600</td>
</tr>
<tr>
<td>744272472</td>
<td>2 x 4700</td>
<td>0,720</td>
<td>360</td>
<td>13000</td>
</tr>
</tbody>
</table>

Warning: Don’t try this at home!

For Demonstration Purposes Only!

Load is 1.5A

And…. CMC

CMC 4.7mH Bifilar Winding
Conducted Emissions Example – Bifilar CMC Results

CMC 4.7mH Bifilar Winding

no load >

load 1.5A>
Conducted Emissions Example – Sector CMC

CMC 47mH sectional winding
Conducted Emissions Example – Sector CMC

CMC 47mH Sectional Winding
Leakage Inductance \( L_s \approx 250\mu H \) (5% of \( L \))
Conducted Emissions Example – Sector CMC Results

CMC 47mH sectional winding

no load >

load 1.5A>
Conducted Emissions Example - Conclusions

- High Frequency Noise Appears Under Load
- Noise is Differential Mode
- Differential Choke
  - Attenuates low frequency noise because of SRF
- Bifilar CMC
  - Does not attenuate because of very low leakage inductance.
- Sector CMC
  - Attenuates both high and low because of leakage inductance with high SRF.
- Chip Bead
  - Without a load there is some affect at high frequencies, but with a load the bead pre-magnetizes and there is no affect at all.
Transformers for EMC – What to Choose

Midcom

Würth Elektronik
Transformers for EMC – No Antennas Please!

Enough Said!

Flying Leads Make Great Antennas.
Estimate Component Losses

- Efficiency is ~ 75-85% Typical
  - 33% Switch
  - 57% Output Rectifiers
  - 5% Magnetics
  - 5% Miscellaneous

So where are your losses?
Where are the losses?
Losses in transformers and inductors

\[ P_{\text{total}} = P_{\text{Cu}} + P_{\text{FE}} \]

- Copper losses
  - DC losses
  - AC losses
    - Skin Effect
    - Proximity Effect
- Core losses
  - Hysteresis loss
  - Eddy current losses
Practical Formulas for Calculation of Temperature Rise $\Delta T$ for WE-PD, WE-DD

**WE-PD Typ „S“ (744778_, 7447789_); WE-DD „S“:**

$$\Delta T \approx \left( \frac{P_{\text{tot}}}{2,875} \right)^{0,826}$$

*P$_{\text{tot}}$ in (mW) and $\Delta T$ in (°C)*

**WE-PD Typ „M“ (744777_, 7447779_); WE-DD „M“:**

$$\Delta T \approx \left( \frac{P_{\text{tot}}}{3,218} \right)^{0,826}$$

*P$_{\text{tot}}$ in (mW) and $\Delta T$ in (°C)*

**WE-PD Typ „L“ (744771_); WE-DD „L“:**

$$\Delta T \approx \left( \frac{P_{\text{tot}}}{6,321} \right)^{0,826}$$

*P$_{\text{tot}}$ in (mW) and $\Delta T$ in (°C)*

**WE-PD Typ „XL“ (744770_); WE-DD „XL“:**

$$\Delta T \approx \left( \frac{P_{\text{tot}}}{8,045} \right)^{0,826}$$

*P$_{\text{tot}}$ in (mW) and $\Delta T$ in (°C)*

**Example: As calculated:**

744 770 147

$P_{\text{tot}}$=233 mW

$$\Delta T = \frac{233}{8.045}^{0,826}$$

= 16,1°C

*Trilogy of Inductors Pages 222–223*
Core/Copper Losses & Efficiency

Copper Losses

- red = 74456168 68uH DCR = 205 mΩ
- blue = 74456147 47uH DCR = 160 mΩ
- green = 7445620 100uH DCR = 290 mΩ

? = 2.2 %
Practical way for core loss calculation $P_{\text{core}}$ by using $I_{\text{max}}$ and ripple current $\Delta I$ for WE-PD

<table>
<thead>
<tr>
<th>PD size</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>XL</td>
<td>$P_{\text{core (mW)}} = 744770 \times 12 \cdot f^{1.274} \left(\frac{\Delta I}{I_{\text{max}}}\right)^{1.9}$</td>
</tr>
<tr>
<td>L</td>
<td>$P_{\text{core (mW)}} = 744771 \times 7.2 \cdot f^{1.274} \left(\frac{\Delta I}{I_{\text{max}}}\right)^{1.9}$</td>
</tr>
<tr>
<td>M</td>
<td>$P_{\text{core (mW)}} = 744777 \times 2 \cdot f^{1.274} \left(\frac{\Delta I}{I_{\text{max}}}\right)^{1.9}$</td>
</tr>
<tr>
<td>S</td>
<td>$P_{\text{core (mW)}} = 744778 \times 1.6 \cdot f^{1.274} \left(\frac{\Delta I}{I_{\text{max}}}\right)^{1.9}$</td>
</tr>
</tbody>
</table>

Trilogy of Inductors
Pages 220–221
What more do you need?

Look at our Book:

Chap.1: Basics
keep it simple, stupid

Chap.2: Components
Descriptions, Applications, Simulation Models and many more

Chap.3: Filter-Circuits
Design, Grounding, Layout, Tips

Chap.4: Applications
Circuit, suggested parts, Layout

Chap.5: Appendices
from A to Z
Transformers for EMC – No External Gaps
Transformers for EMC – No External Gaps

- Center Leg Gap Only
  - Windings Shield
- No Gaps in Outer Legs
  - Nothing to Shield
Transformers for EMC – No EI Core

- EI Core Style
- Mylar or Tape Used for Gap
- Three Unshielded Gaps

Not a good solution!
Transformers for EMC – Gap

- Gap Must be Perpendicular to Flux Lines
  - Here Only One Side is Gapped
- Uneven Gaps Are Inefficient, Why?
  - Core Saturates at Minimum Gap.
  - Requires a Larger Gap
- Also Larger Gap – More Potential EMI
Transformers for EMC – Internal Shields

- Shield both Conducted and Radiated Noise
- **Copper Foil or Wound Magnet Wire?**
  - Copper Foil Shields – Expensive, *Why?*
    - Must Build Shield
    - Must be Cuffed with Tape
    - Winding Machine Stopped to Apply
- All Shields Take Away from Winding Area
How Do External Shields Differ from Internal Shields?

Shields Radiated Noise ONLY!

As Expensive as Internal Shields
Transformers for EMC – Multi-layer Primary Termination

- How does One Terminate a Multi-layer Primary?
- Terminate Start to Switch so Subsequent Layer/s Shield High dv/dt Windings from outside world.

Increasing Voltage $V = L \frac{dl}{dt}$

Subsequent Winding Acts as Shield

Note: Dots on Finish Cont'd. Okay?
Transformers for EMC – Y-Cap Termination

- Noise Couples Through the Transformer via $C_{ww}$
  - Noise Seeks Path to Primary Circuit
  - Without Path, Noise May Become Conducted Emissions
- Y-Cap Across Transformer Reduces Noise
  - Tune the Capacitor for Optimum Loss vs. Noise Reduction
  - Capacitor Usually in the 2.2nF to 4.7nF range
  - Y-Caps to Transformer Terminals not on Switch nor on Diode
  - Close to Transformer as Possible

What Can We Do?

Decrease $C_{ww}$?

What Else Can We Do?
Transformers for EMC – No Varnish or Potting

Radiated Emissions

*Without Potting Material, the Material Passes at Different Frequencies.*
Transformers for EMC - Small Designs

Why Build Smaller Designs?

- Build Smaller More Compact Transformers
- Smaller Transformers have less Parasitics
  - Less Capacitance
  - Smaller Leads (ie. Smaller Antennas)
  - Smaller Gaps
  - Less Leakage Inductance
- Less Conducted and Less Radiated Noise
Transformers for EMC – Power Supply

- Current Compensated Choke WE-FC
- Snubber
- Transformer
- Y-Cap
- Output Filter WE-TI
- Switch IC
Transformers for EMC – Schematic

Current Compensated

Shubber Transformer

Y-Cap

Output Filter

Switch IC
Transformers for EMC – Example 1

- Without Current Compensated Choke
- With Adjusted Snubber
- Without Adjusted Y-Cap

EMC Test Failed

Peak
Avg.
Peak
Avg.
Transformers for EMC – Example 2

- With Current Compensated Choke
- With Adjusted Snubber
- Without Adjusted Y-Cap

EMC- Test Failed
Transformers for EMC – Example 3

- With Current Compensated Choke
- With Adjusted Snubber
- With Adjusted Y-Cap

EMC - Passed
Transformers for EMC – Example 4

- With Current Compensated Choke
- Without Adjusted Snubber
- With Adjusted Y-Cap

Peak
Avg.
Peak
Avg.

EMC- Passed
Transformer for EMC – Conclusion for this Supply

- Necessary to Pass
  - Current Compensated Choke
  - Y-Caps
- Not Necessary to Pass
  - Optimized Snubber
Online:

www.we-online.com
Inductor Selector Guide

WE Inductor Selector
Easy Inductor Selection for DC/DC Converter

Select Converter Topology:

Calculations:

- \( L_{opt} = 24.253 \mu\text{H} \)
- \( I_{rms} = 3.000 \text{ A} \)
- \( I_{peak} = 3.200 \text{ A} \)
- \( \Delta I = 0.600 \text{ A} \)
- \( V_{t} = 0.286 \text{ V} \)
- \( t_{on} = 1.429 \mu\text{s} \)

<table>
<thead>
<tr>
<th>Series</th>
<th>Size</th>
<th>Ordercode</th>
<th>( L [\mu\text{H}] )</th>
<th>( \Delta I_{[%]} )</th>
<th>( I_{\text{in}} [\text{A}] )</th>
<th>( I_{\text{sat}} [\text{A}] )</th>
<th>( L [\text{mm}] )</th>
<th>( W [\text{mm}] )</th>
<th>( H [\text{mm}] )</th>
<th>( \text{Core Mat} )</th>
<th>( \text{Tamb} [^\circ\text{C}] )</th>
<th>( \text{Tmax} [^\circ\text{C}] )</th>
<th>( \text{Shielded} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>WE-PD</td>
<td>XXXL</td>
<td>744770823C</td>
<td>22.000</td>
<td>23.300</td>
<td>3.200</td>
<td>5.500</td>
<td>8.00</td>
<td>12.00</td>
<td>12.00</td>
<td>8.00</td>
<td>Nichel 12%</td>
<td>85</td>
<td>125</td>
</tr>
<tr>
<td>WE-PD</td>
<td>XL</td>
<td>744771122</td>
<td>22.000</td>
<td>31.000</td>
<td>0.370</td>
<td>3.770</td>
<td>12.00</td>
<td>6.00</td>
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Wurth Electronics Midcom Inc.
What more do you need?

Look at our Book:

Chap.1: Basics
keep it simple, stupid

Chap.2: Components
Descriptions, Applications, Simulation Models and many more

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Circuit, suggested parts, Layout

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from A to Z
Any Questions?
Thank you from –
the Wurth Electronics Midcom East Coast

Josh Shakeridge  Brian Wiese  Shereen Abeid  Doug Toth

Simon Vilela  Kari O’Conner  Isabel Cruz  Ira Buerkert  Dave Tompkins