











DEMO STATION: HOW CAPACITORS INFLUENCE THE PERFORMANCE OF A FLYBACK CONVERTER

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WURTH ELEKTRONIK MORE THAN YOU EXPECT

2023 PSMA MAGNETICS WORKSHOP

TEST SETUP

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Taking advantage of the FFT capabilities of Rohde & Schwarz Oscilloscopes for EMI Testing





TECHNICAL SPECIFICATION

DC/DC Flyback-Converter CCM (Forced Continuous Conduction Mode)

Specficication

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- U_{in} = 24V (19-30V)
- $U_{out} = 5V$
- *I*_{out,max} = 5A (25W)
- $f_{sw} \approx 300 \text{kHz}$
- Efficiency $\approx 90\%$
- IC: ADP1071-2 (Analog Devices)
 - with synchronous rectifier
- Transformer: 749119550
- MOSFETs in TO220-package





TEST#3: BACKGROUND - NOISE CATEGORIES

Theory: Noise categories





Differential Mode

Common Mode



TEST#3: BACKGROUND - NOISE CATEGORIES

Theory: DM and CM noise path in a flyback converter





TEST#1: WAVEFORMS - SWITCH NODE VOLTAGE



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TEST#1: WAVEFORMS - INPUT CAPACITOR CURRENT



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TEST#1: WAVEFORMS - INPUT CAPACITOR VOLTAGE RIPPLE





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TEST#2: BOARD CONFIGURATION



TEST#3: BOARD CONFIGURATION





TEST#4: BOARD CONFIGURATION





TEST#4: BOARD CONFIGURATION





TEST#5: BACKGROUND - SWITCH NODE CAPACITANCE



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TEST#6: BOARD CONFIGURATION





TEST#7: BOARD CONFIGURATION





TEST#7: TOTAL CONDUCTED EMISSIONS - LINE





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Combined

Namec	Description
Test#3	Reference (no improvement)
Test#4	Test#3 + RCD-snubber
Test#5	Test#4 + primary to secondary y-capacitors
Test#6	Test#5 + CMC and y-capacitors (CM filter)
Test#7	Test#6 + x-capacitor (DM filter)



<u>CMC COMPARISON - CONDUCTED EMISSIONS - COMMON MODE – 100 KHz - 1 MHz</u>





Common Mode

Name	Description
Test#5 a)	Test#5 + y-capacitors + x-capacitor
Test#7	Test#7 - CMC: 2,2mH/2A MnZn - 744822222
Test#7 e)	Test#7 - CMC: 1mH/3A MnZn - 744822301
Test#7 h)	Test#7 - CMC: 110µH/3A NiZn - 744842311
Test#7 k)	Test#7 - CMC: 5mH/3A Nc -7448023005

CMC Core material:

- MnZn/MnZn
- NiZn
- Nanocrystalline

Note:

different color choice! Test#7: green before → red (for 2,2mH MnZn) Test# 7 h): green (for NiZn)



<u>CMC COMPARISON - CONDUCTED EMISSIONS - COMMON MODE – 10 MHz – 30 MHz</u>





Common Mode

Name	Description
Test#5 a)	Test#5 + y-capacitors + x-capacitor
Test#7	Test#7 - CMC: 2,2mH/2A MnZn - 744822222
Test#7 e)	Test#7 - CMC: 1mH/3A MnZn - 744822301
Test#7 h)	Test#7 - CMC: 110µH/3A NiZn - 744842311
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CMC Core material:

- MnZn/MnZn
- NiZn
- Nanocrystalline

Note:

different color choice! Test#7: green before → red (for 2,2mH MnZn) Test# 7 h): green (for NiZn)



<u>CMC COMPARISON: CONDUCTED EMISSIONS - DIFFERENTIAL MODE - 10 MHz – 30 MHz</u>





Differential Mode

Name	Description
Test#5 a)	Test#5 + y-capacitors + x-capacitor
Test#7	Test#7 - CMC: 2,2mH/2A MnZn - 744822222
Test#7 e)	Test#7 - CMC: 1mH/3A MnZn - 744822301
Test#7 h)	Test#7 - CMC: 110µH/3A NiZn - 744842311
Test#7 k)	Test#7 - CMC: 5mH/3A Nc -7448023005

CMC Core material:

- MnZn/MnZn
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- Nanocrystalline

Note:

different color choice! Test#7: green before → red (for 2,2mH MnZn) Test# 7 h): green (for NiZn)



<u>CMC COMPARISON: BACKGROUND - DIFFERENTIAL MODE - 100 kHz – 1 MHz</u>

REDEXPERT: Differential Mode Impedance



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TEST#3-7: CONDUCTED EMISSIONS - EMI LABRATORY

Test setup





EMI LABRATORY VS. PRECOMPLIANCE - CONDUCTED EMISSIONS - LINE



Name	Description
Test#3	Reference (no improvement)
Test#4	Test#3 + RCD-snubber
Test#5	Test#4 + primary to secondary y-capacitors
Test#6	Test#5 + CMC and y-capacitors (CM filter)
Test#7	Test#6 + x-capacitor (DM filter)

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TEST#3-7: CONDUCTED EMISSIONS - LTSPICE

Link to simulation folder



LTSPICE VS. MEASUREMENT - TOTAL CONDUCTED EMISSIONS - LINE



Name	Description
Test#3	Reference (no improvement)
Test#4	Test#3 + RCD-snubber
Test#5	Test#4 + primary to secondary y-capacitors
Test#6	Test#5 + CMC and y-capacitors (CM filter)
Test#7	Test#6 + x-capacitor (DM filter)

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