

# TI POWER-SUPPLY FILTER ICs

New Product  
Update

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- Product Line Marketing

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# Agenda

- Introduction & background to a new product category
- Product overview of stand-alone AEF IC
- Results
- Design tools & resources

Please feel free to “chat” with Ben Chan, Systems Engineer who is available to answer any questions you have throughout this presentation.

# New product category on TI.com

## Power supply filter ICs

Includes a new product family of  
Common-mode active EMI filter ICs

The screenshot displays the Texas Instruments website interface. The left sidebar lists various product categories, with 'Power management' highlighted by a red circle. A red arrow points from this circle to the 'Power-supply filter ICs' category, which is also circled in red at the bottom right of the main content area. The main content area shows a grid of product categories under the 'Power management' heading, including AC/DC & isolated DC/DC switching regulators, Battery management ICs, DC/DC switching regulators, DDR memory power ICs, Digital power ICs, Linear & low-dropout (LDO) regulators, MOSFETs, Multi-channel ICs (PMICs), Power over Ethernet (PoE) ICs, Power switches, and Power-supply filter ICs. The page number '3' is visible in the bottom right corner.

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**Power management**

AC/DC & isolated DC/DC switching regulators  
Flyback controllers  
Isolated DC/DC converters & modules  
LLC controllers  
Power factor correction (PFC) controllers  
PWM controllers  
SR & load share controllers

**Battery management ICs**  
Battery authentication ICs  
Battery charger ICs  
Battery fuel gauges  
Battery monitors & balancers  
Battery protectors

**DC/DC switching regulators**  
Buck-boost & inverting regulators  
Charge pumps (inductorless)  
Step-down (buck) regulators  
Step-up (boost) regulators

**DDR memory power ICs**

**Digital power ICs**  
Digital power control drivers & powertrain modules

**Linear & low-dropout (LDO) regulators**

**MOSFETs**  
N-channel MOSFETs  
P-channel MOSFETs  
Power blocks  
Power stages

**Multi-channel ICs (PMICs)**

**Power over Ethernet (PoE) ICs**  
Power sourcing equipment  
Powered devices

**Power switches**  
eFuses & hot swap controllers  
High-side switch controllers  
High-side switches  
Ideal diode/ORing controllers  
Load switches  
Low-side switches  
Power muxes  
Solid-state relays

**Power-supply filter ICs**

3

# Power-supply filter ICs – active EMI filter ICs

## Reduce system size, weight and cost with stand-alone AEF ICs

Mitigating electromagnetic interference (EMI) has become more challenging given the large passive filters in power-supply systems.

By acting as a capacitance amplifier, the active EMI filter (AEF) integrated circuits (ICs) in our new power-supply filter IC portfolio make it possible to achieve up to 30 dB of additional EMI attenuation, reducing the inductance value of chokes in common-mode filters as much as 80%.

# Solving key design challenges with AEF ICs



Marginally meeting EMI standards



EMI filter sizes too big

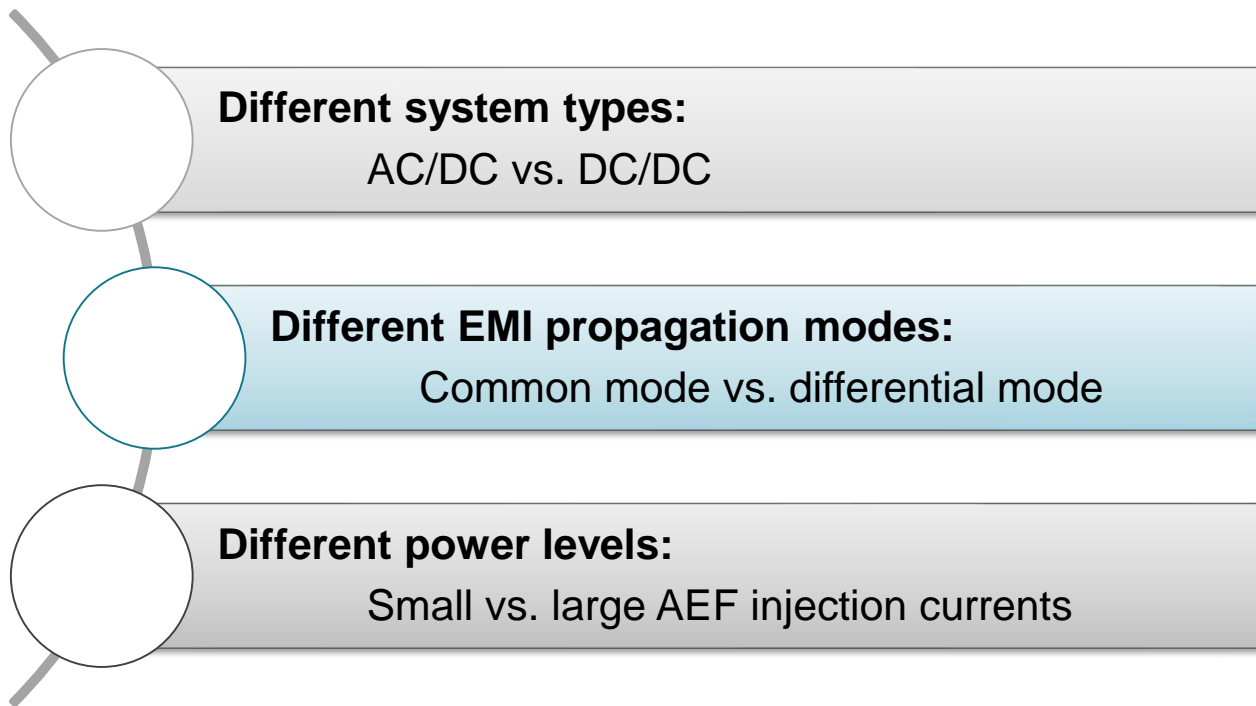


Additional EMI attenuation of  
~30 dB  
Quick time to market



Reduce system size, weight and  
cost  
More than 50% smaller  $\pi$  filters;  
80% lower choke inductance  
Reduce heat and improve  
reliability

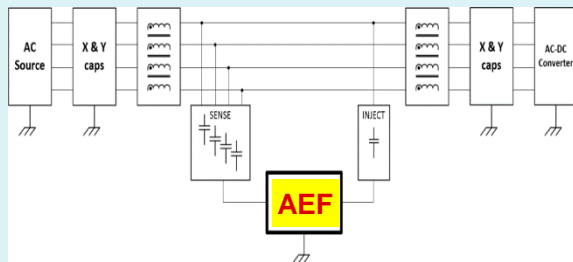
# Where are AEFs used?



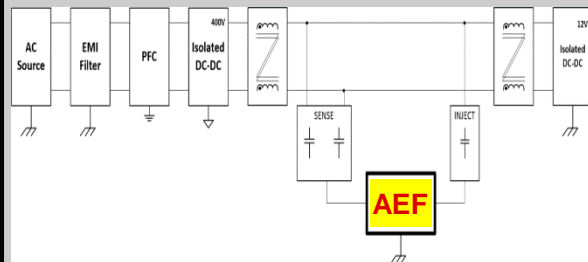
# Where AEF can help

Address common-mode (CM) and differential-mode (DM) EMI challenges for AC/DC and DC/DC systems.

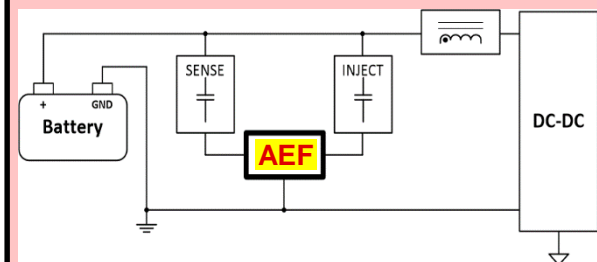
## AC grid-side CM



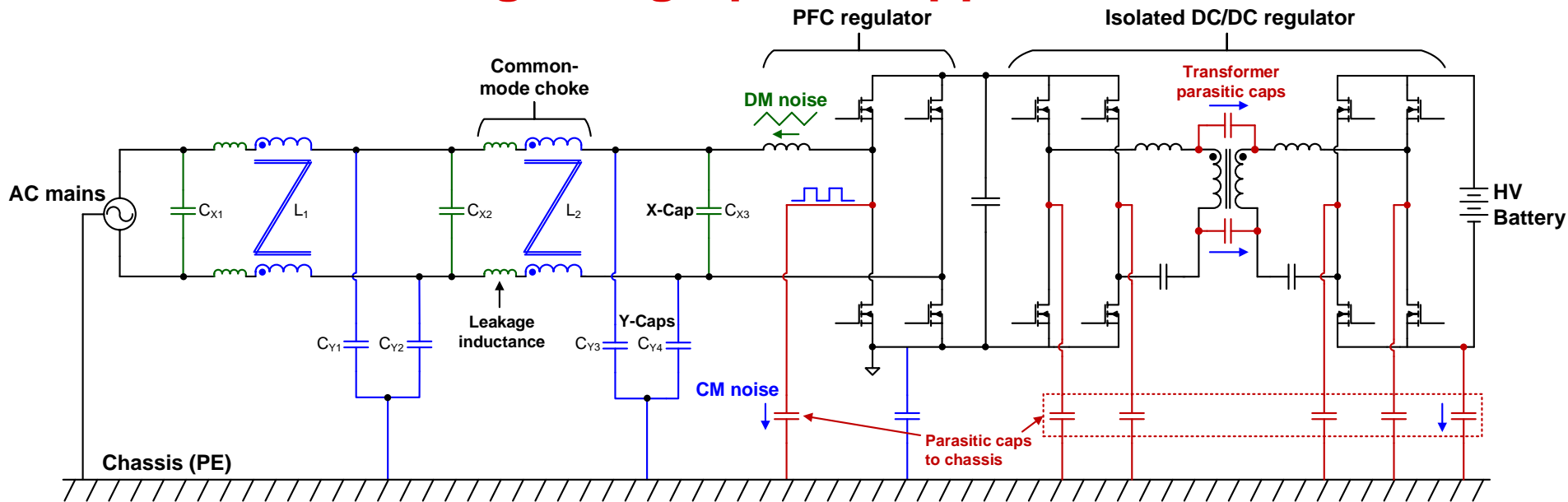
## HV/LV DC-side CM



## DC/DC-side DM



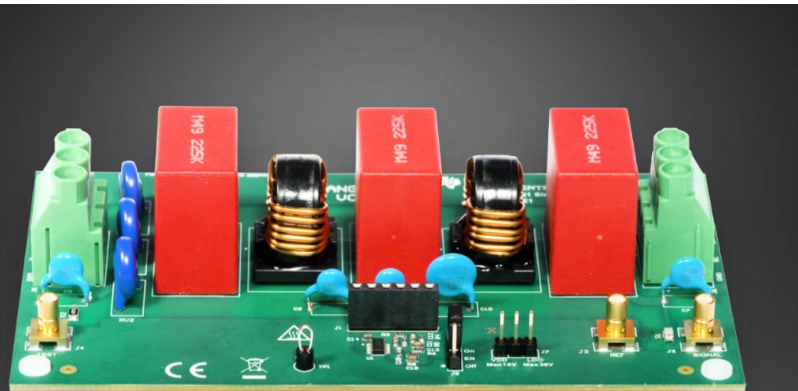
# DM vs. CM filtering in high-power applications



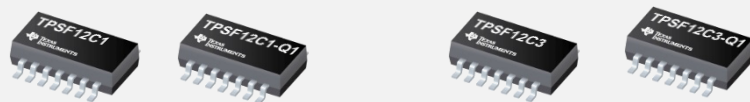
- Both DM noise and CM noise are filtered using multi-stage LC filters
- For **DM filtering**, C is large valued ( $\sim \mu\text{F}$ ), so **L can be relatively small ( $\sim \mu\text{H}$ ) – typically obtained from leakage inductance of the CM choke**
- For **CM filtering**, allowed Y-cap is limited ( $\sim \text{nF}$ ) by leakage-current regulatory requirements (touch current), so **L<sub>CM</sub> needs to be large ( $\sim \text{mH}$ ) – CM choke dominates the total size of the EMI filter**



# Mitigate common-mode emissions to meet stringent EMI standards with stand-alone active EMI filters



CISPR



TI's active EMI filter ICs meet IEC 61000-4-5 surge immunity requirements, thus minimizing the need for external protection components, such as transient voltage suppression (TVS) diodes.

Engineers will be able to address EMI design challenges and meet CISPR 11, CISPR 32 and CISPR 25 EMI requirements.

# High-power applications for active EMI filters

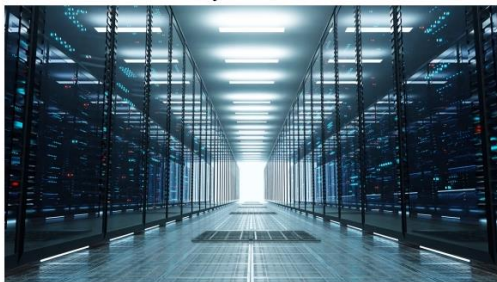
Automotive on-board chargers (OBCs)



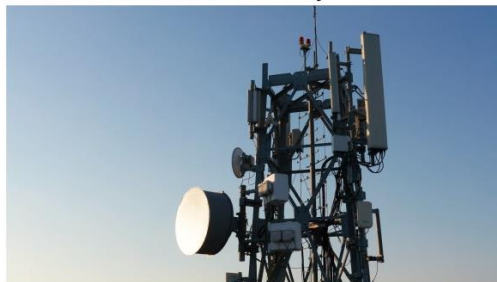
Single-phase and three-phase industrial systems



Power delivery – Server rack PSUs



Communications systems

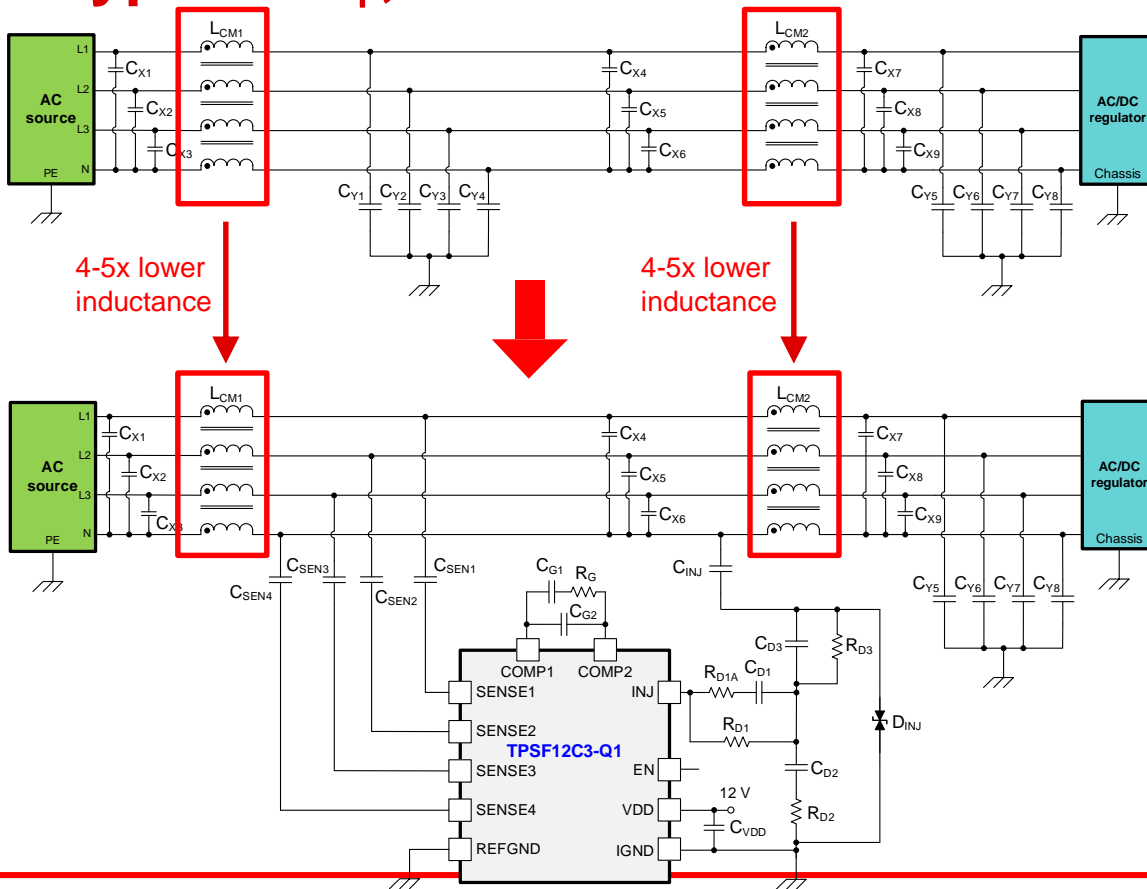


- High-power applications in highly constrained system environments
- Strict EMI standards
- Common-mode (CM) emissions dictate filter size

**Reduce the size, weight and cost of traditional passive EMI filter designs with TI's active filter solution**



# Typical 3- $\phi$ , 4-wire AEF schematic

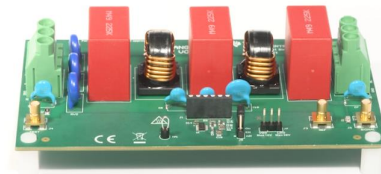


## Three-phase schematic without AEF:

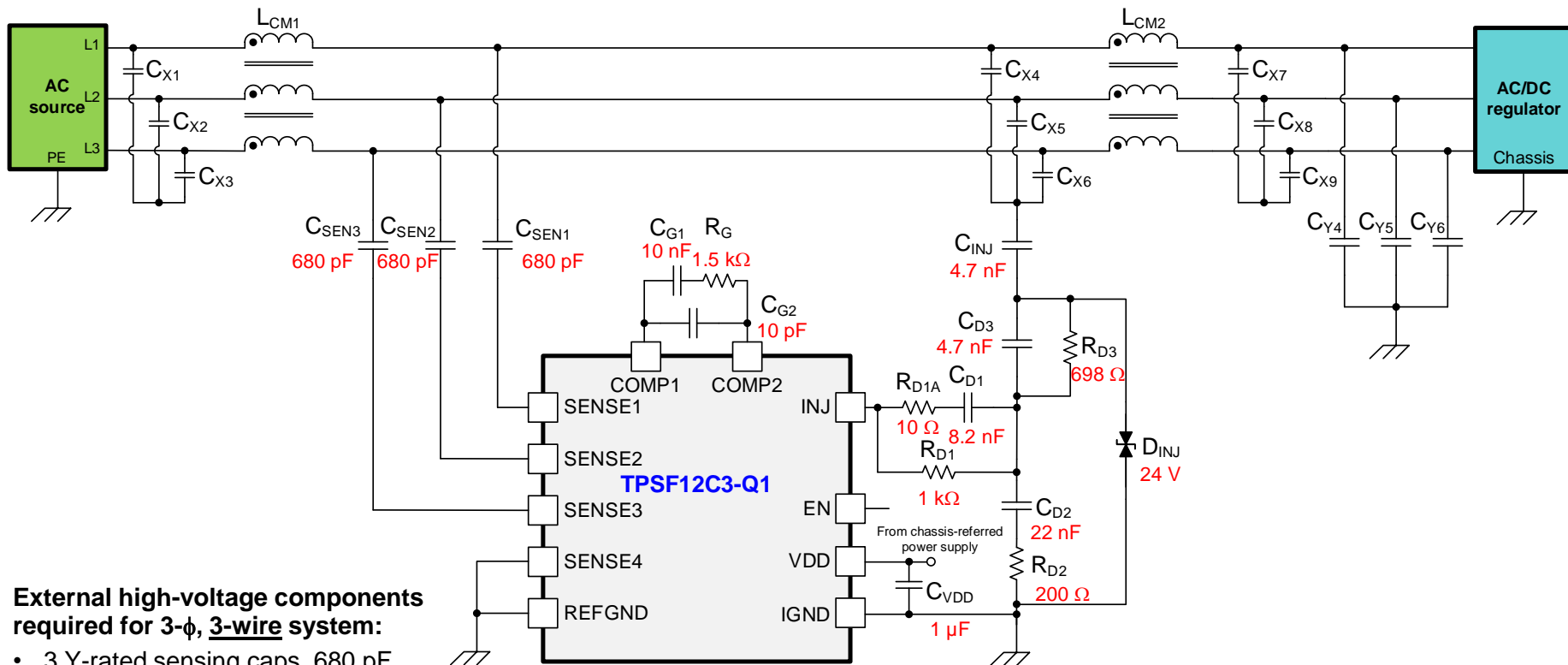
- Two-stage **passive** filter circuit with three-phase mains input
- CM chokes  $L_{CM1}$  and  $L_{CM2}$  dominate the total filter size
- Total Y-capacitance is limited

## Three-phase schematic with AEF:

- Equivalent **active filter circuit**
- CM chokes  $L_{CM1}$  and  $L_{CM2}$  are each 4-5 $\times$  lower in inductance with AEF
- Four sense capacitors, one inject capacitor
- No change in touch current amplitude during fault conditions



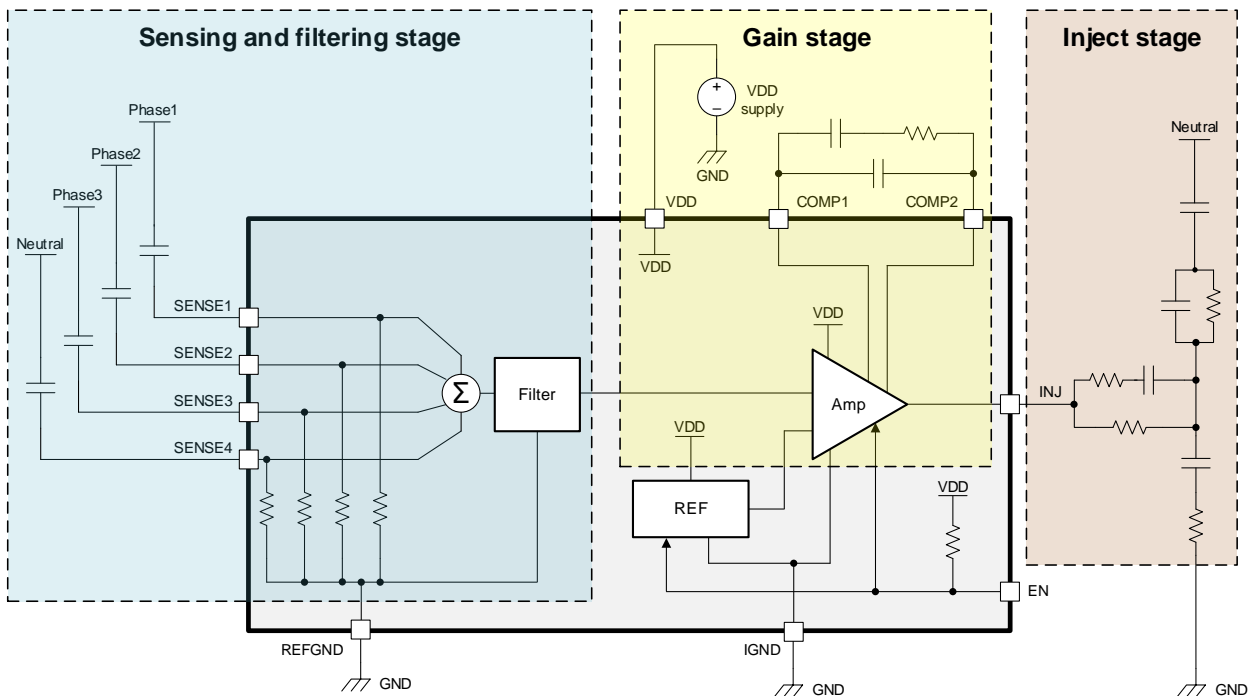
# Typical 3- $\phi$ , 3-wire AEF schematic (no neutral)



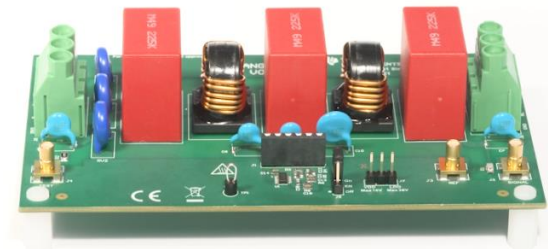
**External high-voltage components required for 3- $\phi$ , 3-wire system:**

- 3 Y-rated sensing caps, 680 pF
- 1 Y-rated inject cap, 4.7 nF

# Functional block diagram of a three-phase AEF circuit



- The AEF IC rejects AC line frequency (50 Hz, 60 Hz) and differential-mode disturbances
- The design includes sensing, gain and inject stages

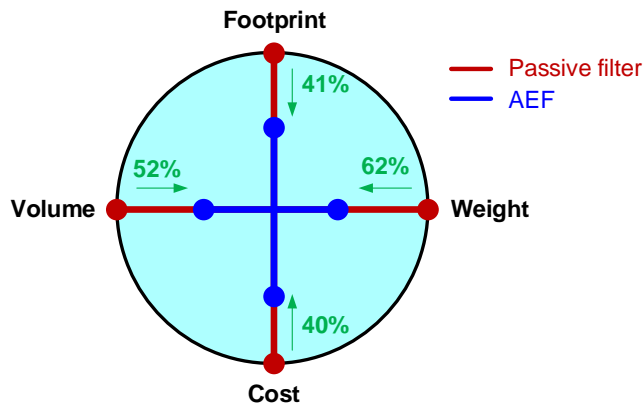


# CM choke comparison – Active vs. passive designs

2 mH  
(with AEF)



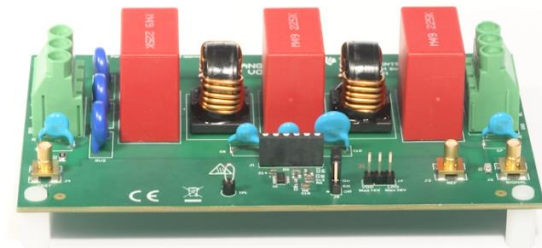
12 mH  
(no AEF)



- Consider a single-phase design rated for 10 A
- CM chokes decrease from 12 mH (passive design) to 2 mH (active design), while achieving similar EMI performance
- Large reductions in CM choke parameters: footprint, volume, weight, power loss and cost

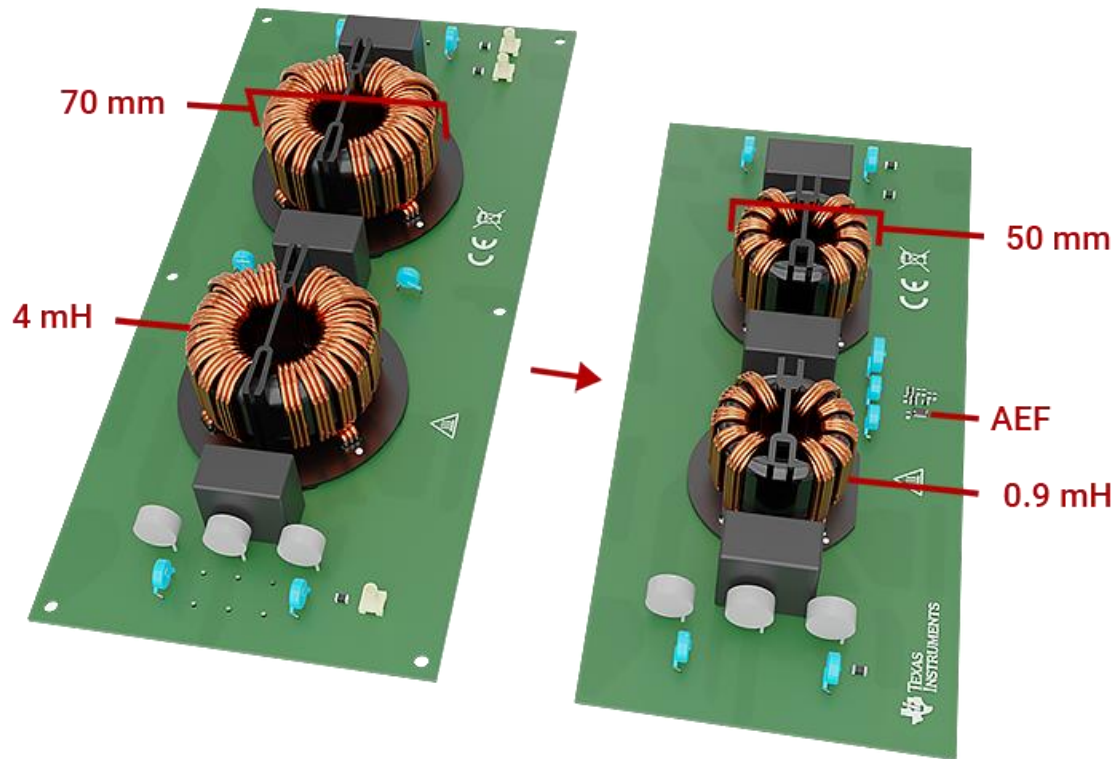
Filter	CM choke part number	Qty	Inductance (mH)	Winding DC resistance (mΩ)	Size (L × W × H, mm)	Total mass (g)	Power loss (W)
Passive	7448051012	2	12	15	23 × 34 × 33	72	6.0
Active	7448031002	2	2	6	17 × 23 × 25	20	2.4

**AEF acts as a capacitive amplifier enabling the EMI filter chokes to be significantly reduced.**





# Example of filter size reduction using AEF for a design rated at 40 A



- CM chokes reduce from 4 mH (no AEF) to 0.9 mH (with AEF)
- Component diameter reduces from 70 mm to 50 mm



## Features

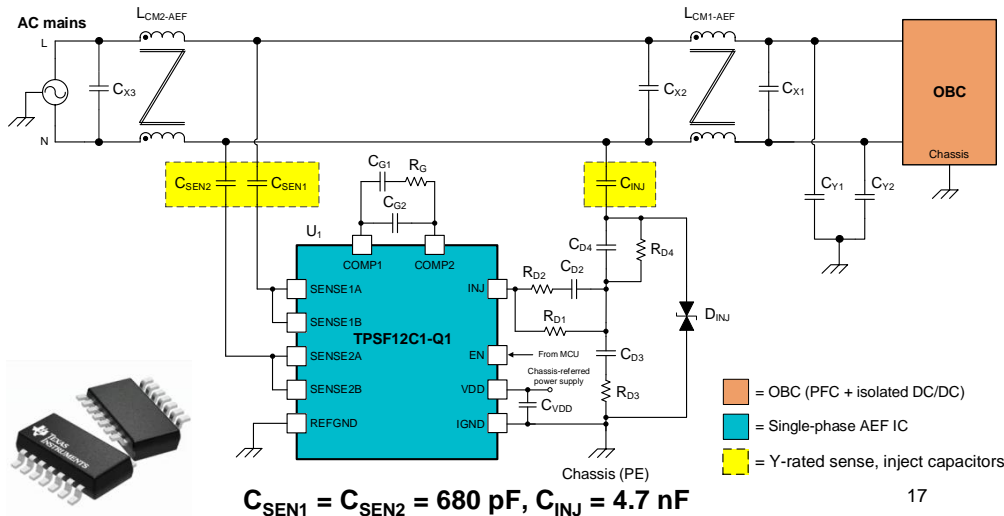
- **Low impedance over EMI concerned frequency range:**
  - 150 kHz to 3 MHz
- **Internal/external protection for IEC 61000-4-5 surge (5 kV)**
- **Fundamental converter frequency:** supports up to 500 kHz
- **Supports low-value capacitors (SENSE, INJECT)**
- **Integrated compensation network**
- **Simple external configuration**
- **Wide power supply range:** 8 V to 16 V
- **Enable pin feature**
- **Temperature ranges:**
  - IC junction: -40°C to 150°C
  - Operating ambient: -40°C to 105°C
  - Thermal shutdown: 175°C
- **14-pin TSOT-23 package**

## Applications

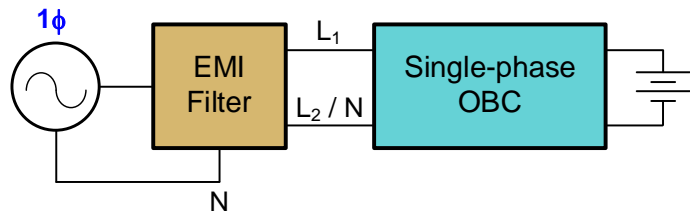
- On-board charger (OBC) for electrical vehicles (EVs), BMS
- PD for Servers, Avionics, Test & Measurement, FA
- Telecom AC/DC rectifiers

## Benefits

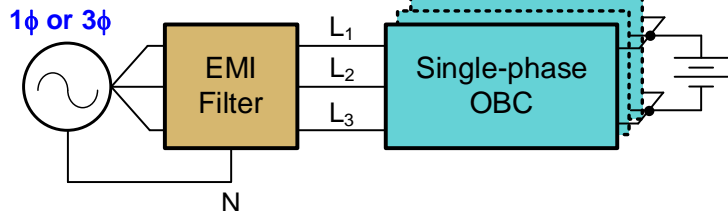
- **Reduces the size and cost of the required Front-End Filter**
  - CISPR 25 (Class 5) and CISPR 11, 32 (Class A or B)
- **Supports high-power (1kW+), high-voltage applications**
- **Optimized for high-frequency, high-power systems**
- **Low line-frequency leakage current (typ ~570  $\mu$ A @ 253 Vac)**
- **Easy to Use – no loop compensation required**
- **Low BOM cost solution**



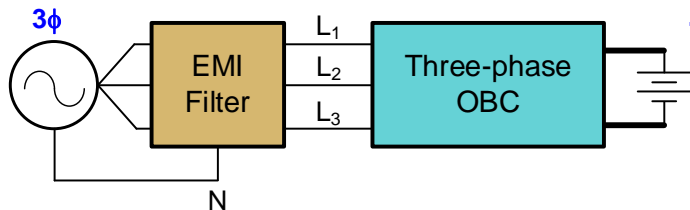
# Automotive on-board charger (OBC) application example



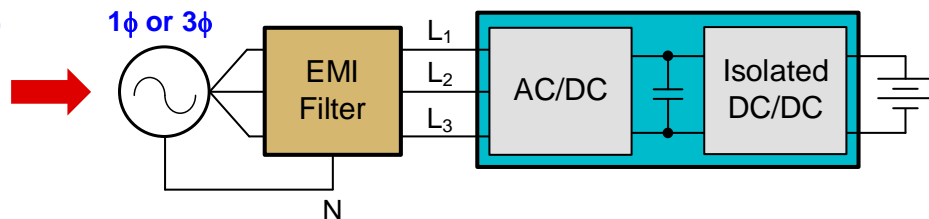
Single-phase  
OBC architecture  
(1- $\phi$  input only)



Single-phase  
modular OBC  
architecture  
(1- $\phi$  or 3- $\phi$   
combo input)



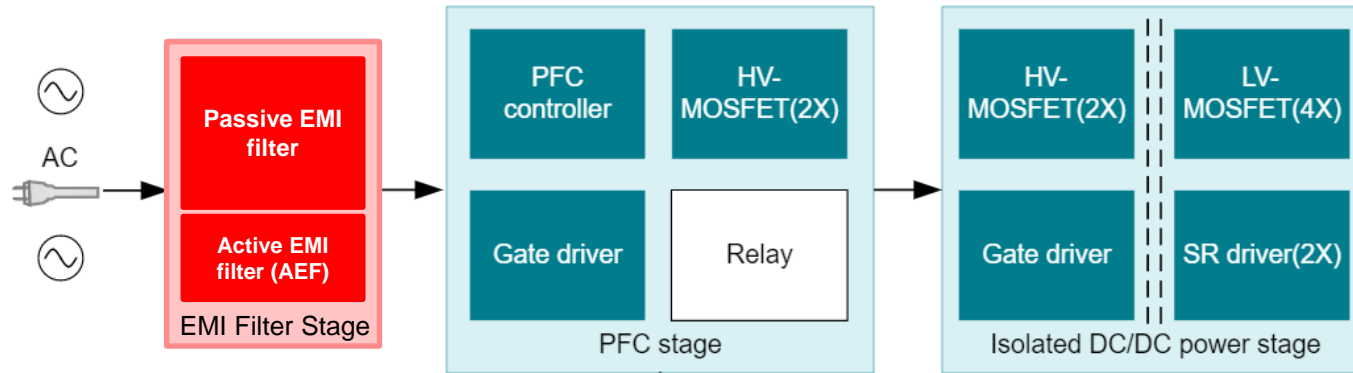
Three-phase OBC  
architecture  
(1- $\phi$  or 3- $\phi$   
combo input)



**OBC two-stage approach – PFC front-end +  
isolated DC/DC for  $V_{BATT}$  and  $I_{BATT}$  regulation**

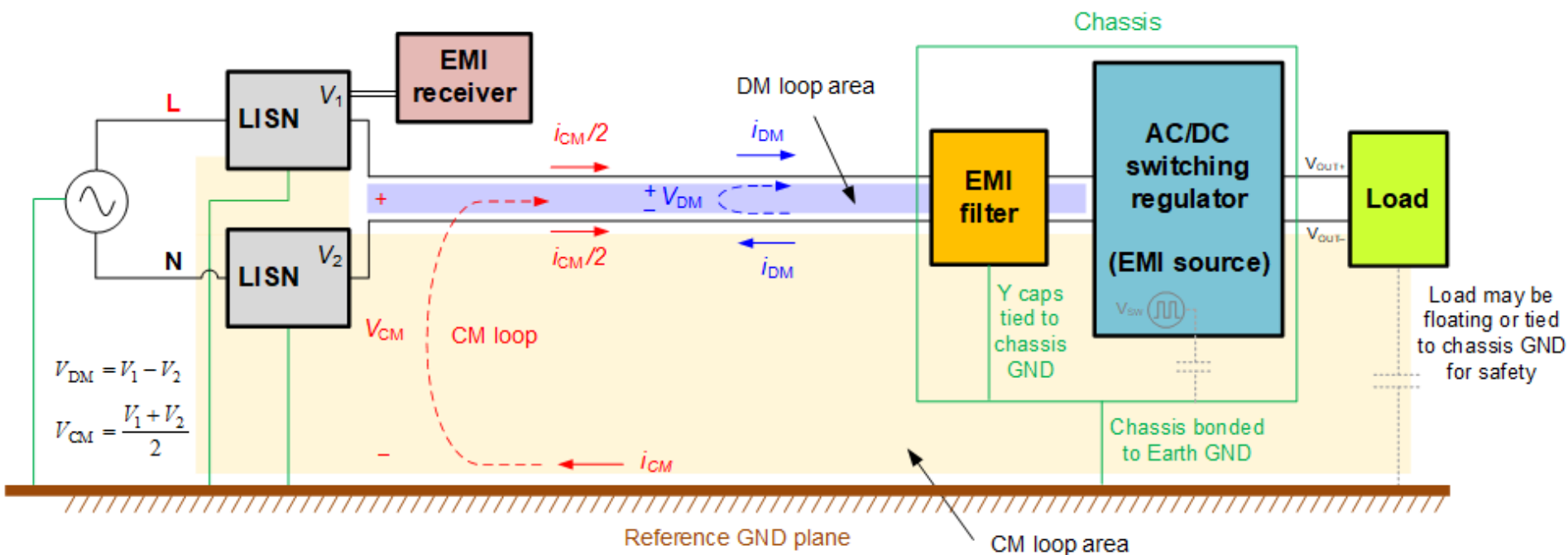
- Level 1 charging (residential): 1 $\phi$  – 1.92kW to 7.4kW – 120V/240Vac (US), 230Vac (EU)
- Level 2 charging (commercial): 3 $\phi$ /1 $\phi$  – 11kW, 22kW – 208Vac to 400Vac
- Y-cap leakage current – limited for safety
- EMI filters ~30% of the overall volume

# Server power supply unit (PSU) application example

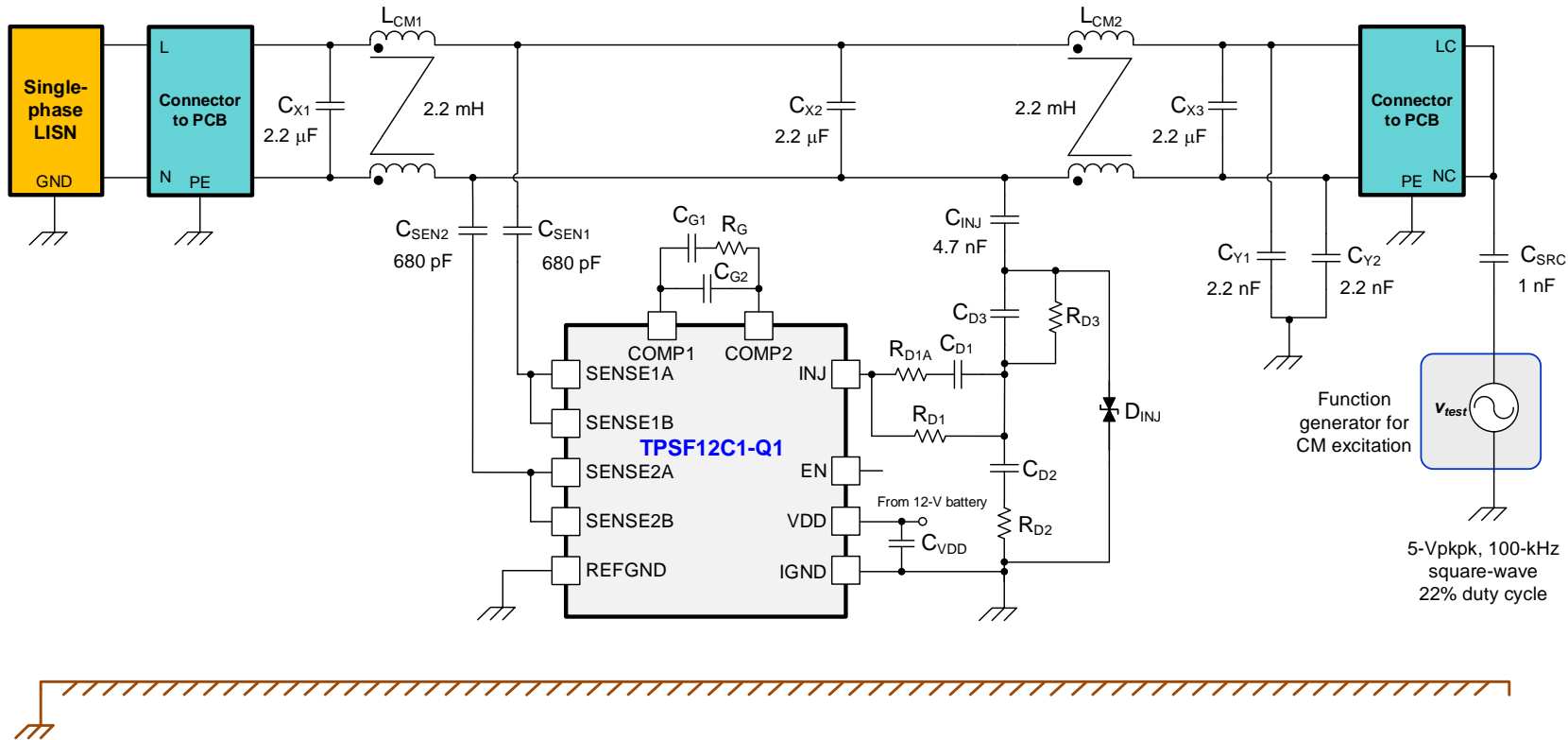


- Effective common-mode (CM) EMI mitigation in typical server power delivery (PD) systems
  - 1 $\phi$  AEF for 1.5 to ~3kW
  - Tight spec on leakage/touch current (e.g. 0.75mArms) implies low total Y-capacitance
- AEF benefits align with key care abouts in server PSU designs
  - Size reduction
  - Reduced heat dissipation
- Server PSU reference designs available on [ti.com](https://www.ti.com)

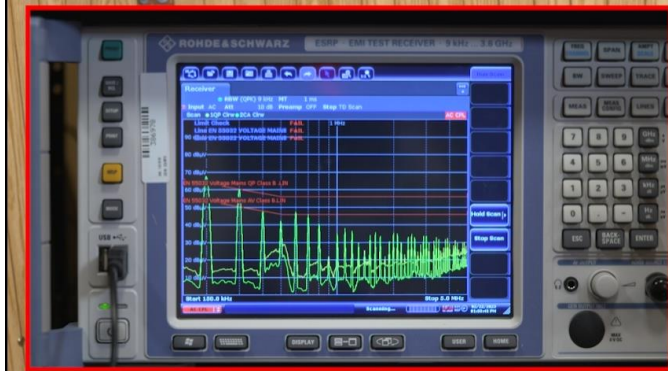
# 1- $\phi$ EMI measurement setup



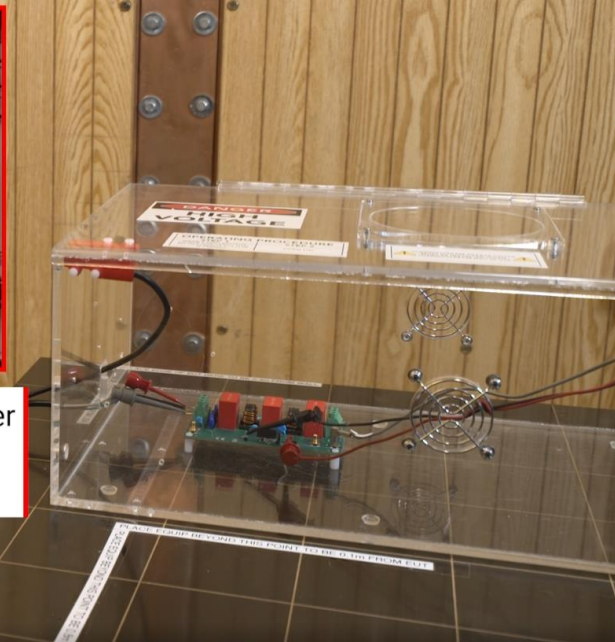
## Low-voltage test setup – with square wave signal injection



# EMI chamber – CISPR 32 measurement setup



- Conducted emissions test setup in EMI chamber
- CISPR 32 measurement with dual LISN
- EMI test receiver with RBW setting of 9 kHz

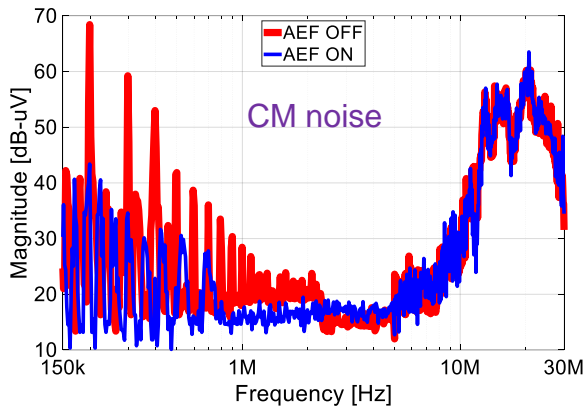


- CISPR 32 conducted emissions test setup in EMI chamber
- CISPR 32 measurement with dual LISN
- EMI test receiver with RBW setting of 9 kHz
- TPSF12C1-Q1 tested with square wave signal of 5Vpkpk at 100kHz

# Measured results – with single-phase PFC

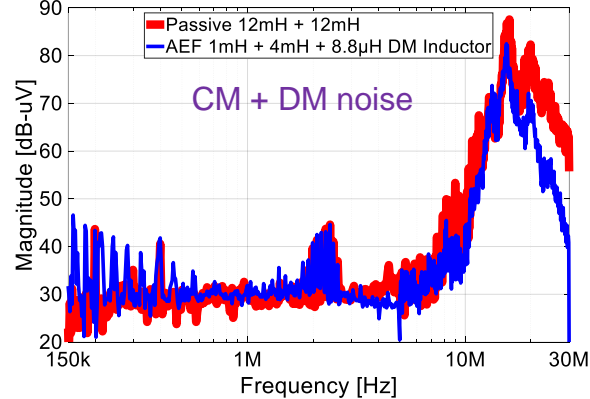
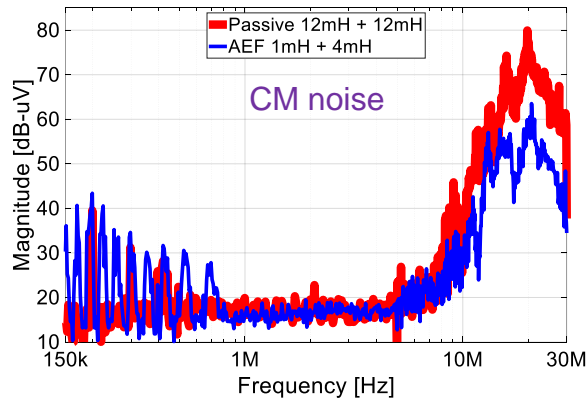
Prototype IC tested with TI reference design **TIDM-1007** totem-pole PFC converter

**15-30dB more attenuation  
with AEF ON vs OFF**



- AEF effective from 150 kHz up to few MHz
- Smaller chokes enabled by AEF have smaller parasitic capacitance → lower noise @ 10–30 MHz

**55% smaller chokes  
for comparable EMI performance**



Passive



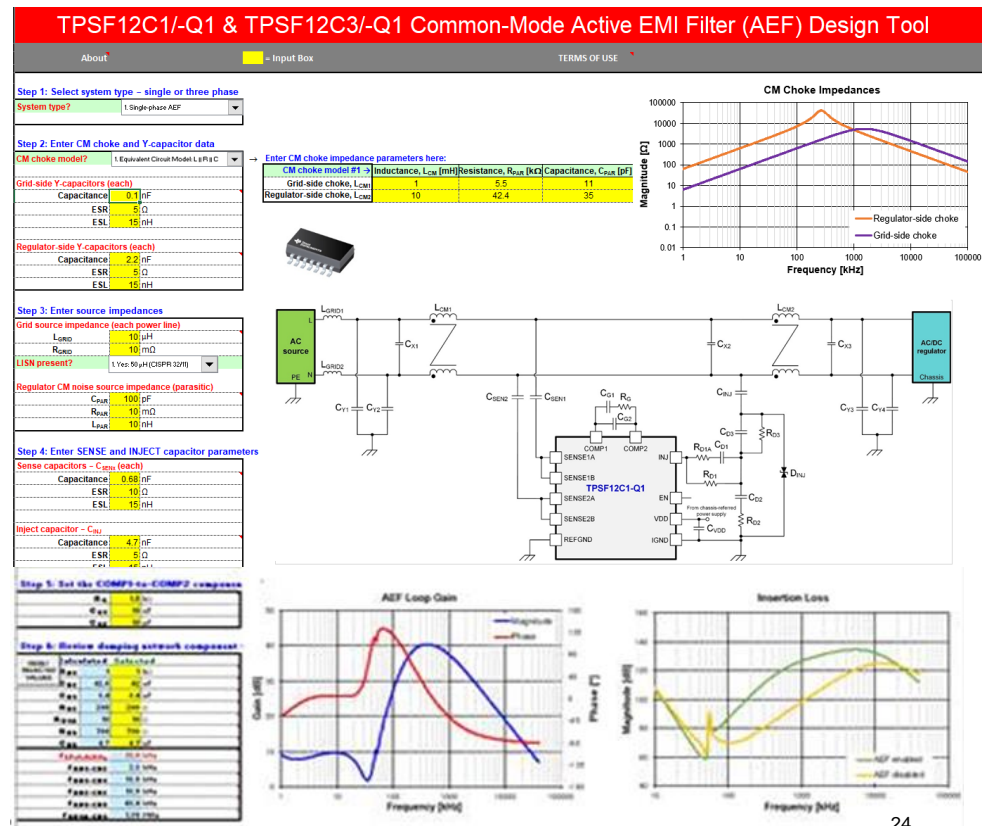
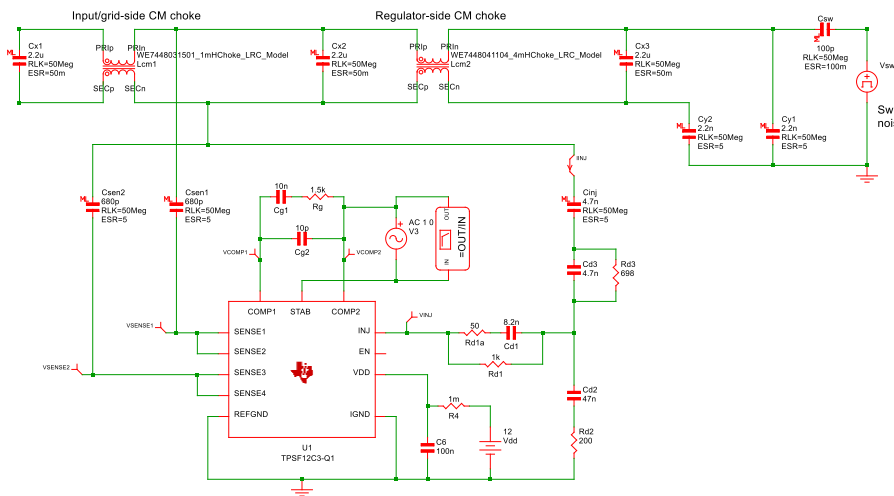
Active



# Design tools and resources

## Resources on TI.com:

- Simulation models – PSPICE and SIMPLIS
- Quickstart calculator – Excel
- PCB layout – Altium source files





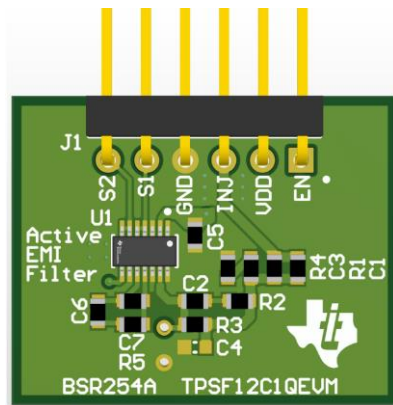
# AEF IC package and evaluation modules

14 DYY  
(TSOT-23)



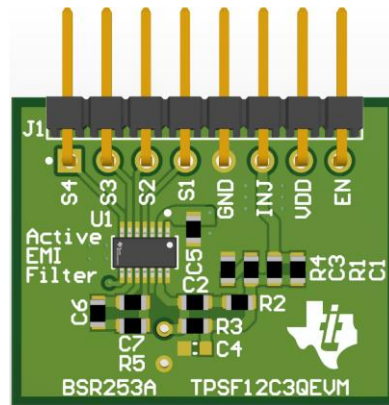
Specs	14-pin DYY
Package body size	4.2 × 2.0mm
Body size with leads	4.2 × 3.26mm
Thermal R <sub>θJA</sub>	94°C/W
Max junction temperature	150°C

Single-phase EVM



20 mm × 25 mm × 5.3 mm

Three-phase EVM



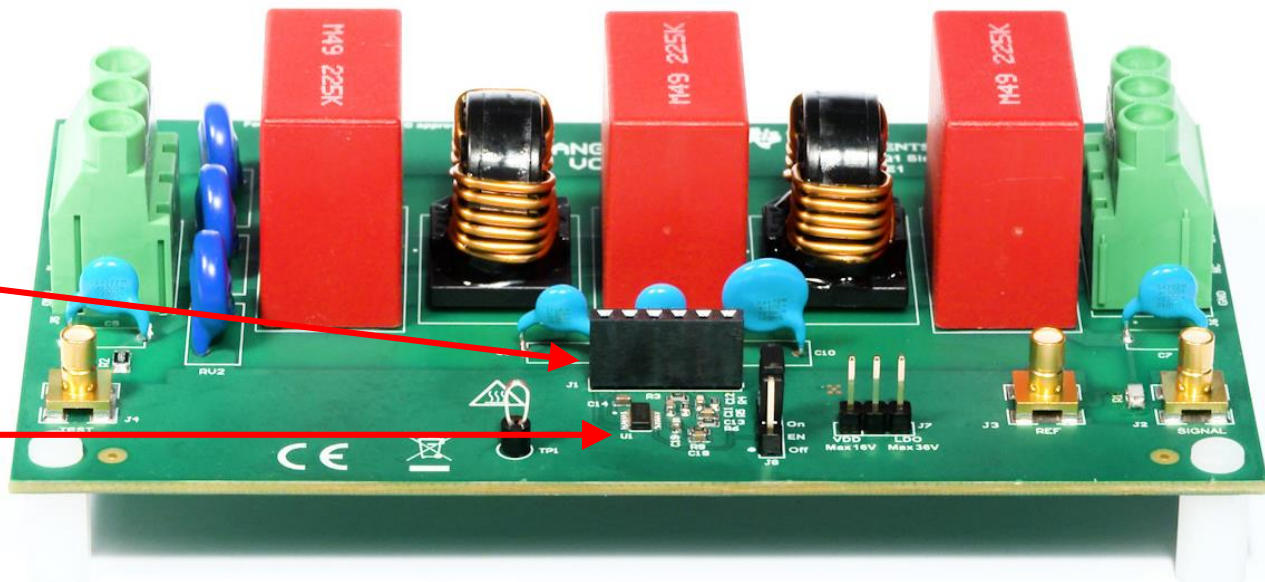
20 mm × 25 mm × 5.3 mm

- EVMs comprise IC (TSOT-23 package) and low-voltage passives
- Single-phase EVM has:
  - 6-pin header with 2.54 mm (100 mil) pin pitch; example: [TSW-106-08-G-S-RA](#)
  - Can mate with female header on EMI filter board; example: [SSW-106-01-G-S](#)
- Three-phase EVM has:
  - 8-pin header with 2.54 mm (100 mil) pin pitch; example: [TSW-108-08-G-S-RA](#)
  - Can mate with female header on EMI filter board; example: [SSW-108-01-G-S](#)

# AEF system integration options

**Option 1:** plug the EVM into the EMI filter board

**Option 2:** put IC and LV passive components directly on the EMI filter board



Reduce the size of  
chokes by up to 50%

[Visit \[www.ti.com/AEF\]\(http://www.ti.com/AEF\)](http://www.ti.com/AEF)

**Visit [www.ti.com/npu](http://www.ti.com/npu)**

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