# *Bourns Magnetic Components in Electric Vehicles*

Kyle Moldenhauer
Achilles Chiotis

Magnetics Marketing

September 2021

BOURNS®

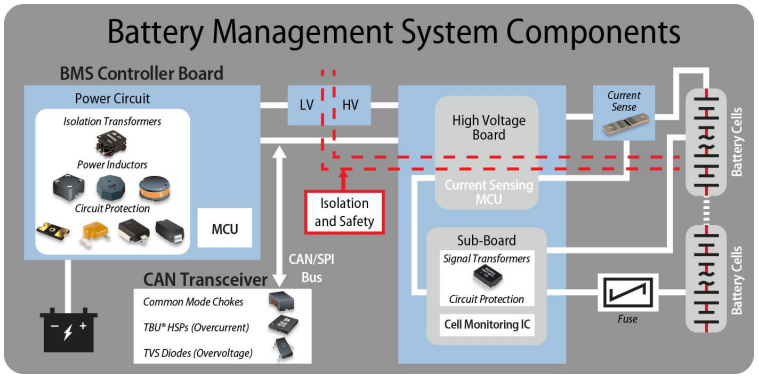
# Agenda

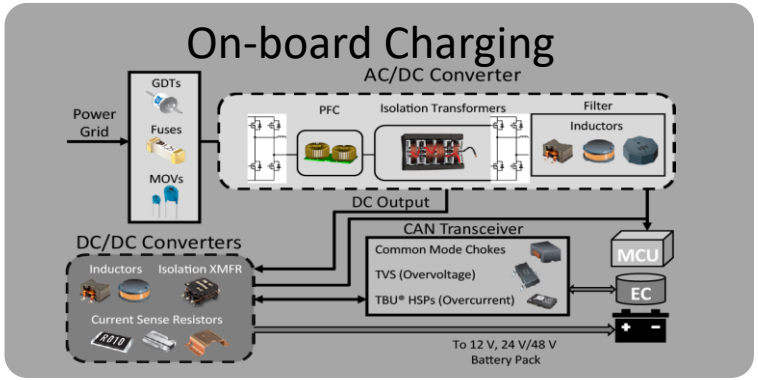
- Electric Vehicle Market Trends
- Magnetic Components in EVs
  - OBC, BMS, DC Charging
- Bourns Power and Signal Magnetic Components
- Recent Reference Designs
- Success Stories
  - Bourns Designs in EVs
- Recommendations

# Electric Vehicle (EV) Market

**EV = BEV (battery EV) + PHEV (Plug-In Hybrid EV)**

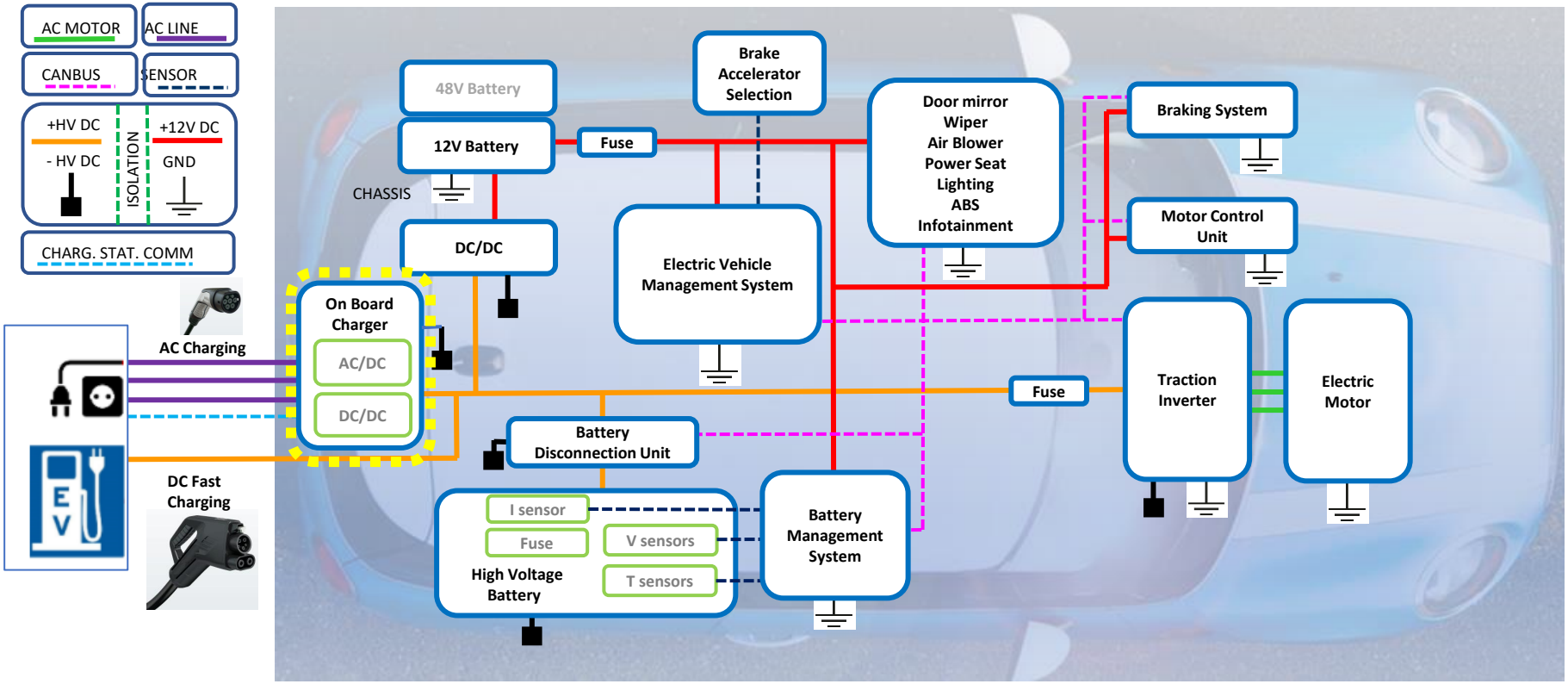
- Massive industry investments in EV vehicles and infrastructure
  - >10m EVs on the roads in 2020, estimated >31m by 2030
  - >1.3m charging stations in 2020, estimated >5m by 2030
- Battery electric models drive EV expansion
- Fast charging (>22KW) drive charging infrastructure expansion
- Growing demand for AEC-Q200 certified magnetic components, >$400M estimated market size in 2022



# Magnetics in On Board Chargers

# EV architecture



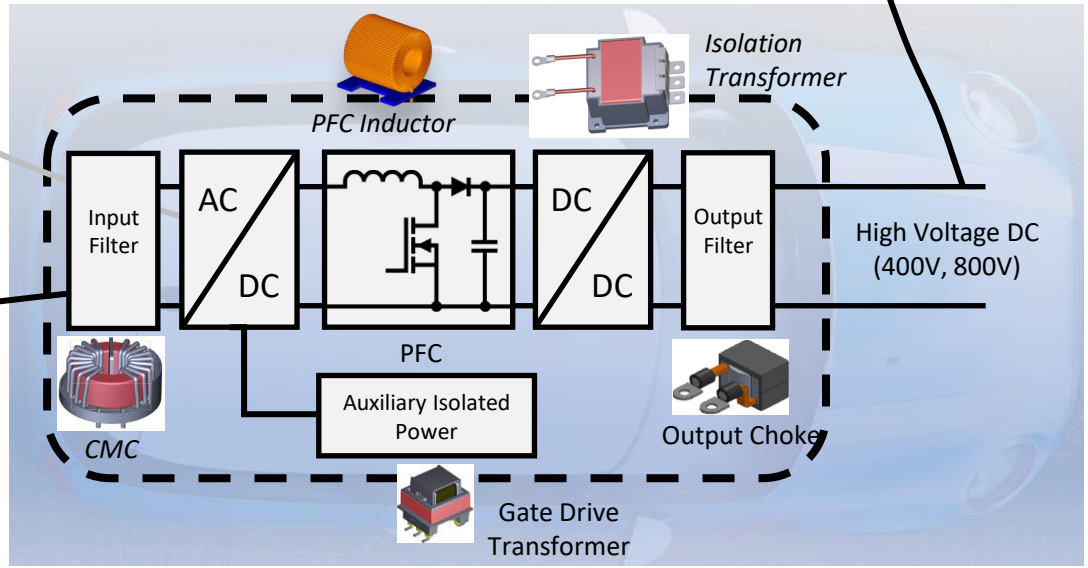
# On Board Charger Architecture

- *6-8kW likely to become std for PHEVs.*
- *11kW likely to become std for BEVs.*
- *Versions up to 22kW*

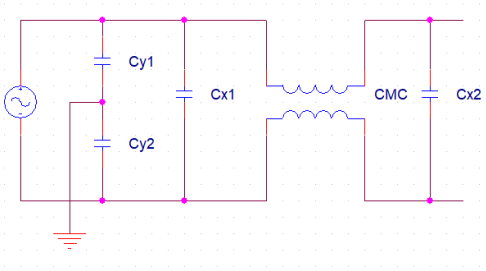
**DC charging station, level 3 Fast chargers**
*200-920Vdc up to 240kW*
*Dedicated EVSE (Electric Vehicle Supply Equipment)*

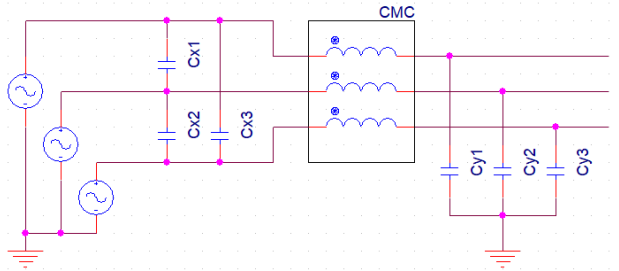
**AC charging station, level 1**
*Single phase 120/230Vac*
*12-20A, <4kW;*
*Standard wall power outlet*

**AC charging station, level 2**
*Single phase / Three phase*
*230/400Vac, <20kW;*
*Dedicated EVSE (Electric Vehicle Supply Equipment)*



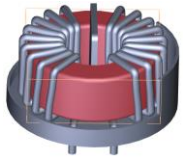
# OBC – Input Filter

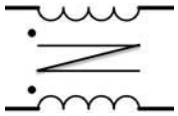


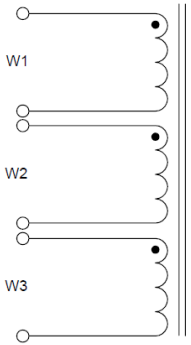




**Single phase Input AC Common Mode Chokes**

- AEC-Q2000
- Inductance 3.7mH
- Dc Resistance 4.5mΩ
- Turn ratio 1:1
- HI-POT 2.5kV
- $I_{RATED}$ 40A
- Package 42x42x24mm

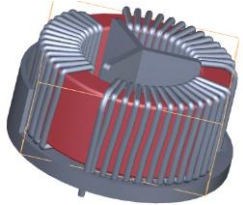







**Three phase Input AC Common Mode Chokes**

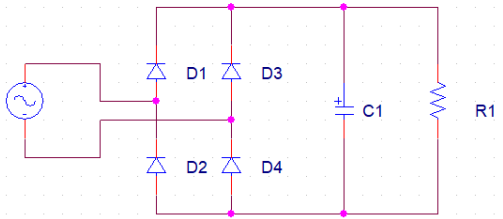
- AEC-Q2000
- Inductance 3.5mH
- DC Resistance W1/W2 10mΩ
- Turn ratio 1:1
- HI-POT 2.5kV
- $I_{RATED}$ 32A
- Package 64x64x32mm

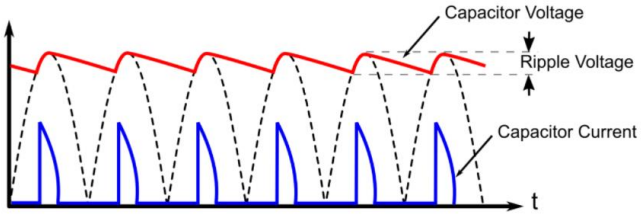


# OBC – AC/DC Converter + PFC

**Passive PFC Disadvantages**

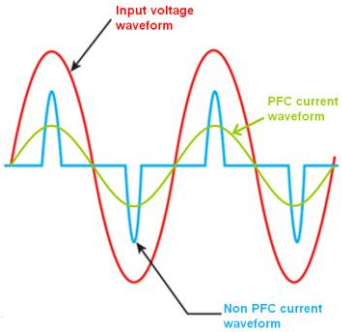
- Size (C, L)
- High Total Harmonic Distortion (THD)
- Low Power Factor (<0.75)
- Unwanted resonance

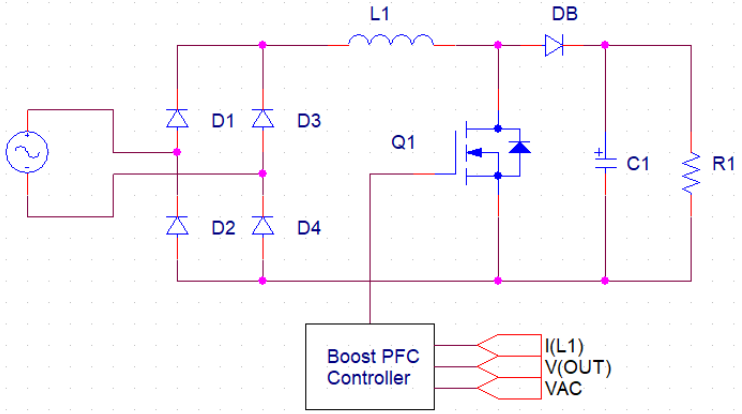



**Conventional Boost PFC**

- DB: ultrafast diode/Sic Schottky for lower losses
- Up to 96% efficiency
- Typical operating frequency 70KHz
- CCM: lower EMI, good balance ripple/switching losses

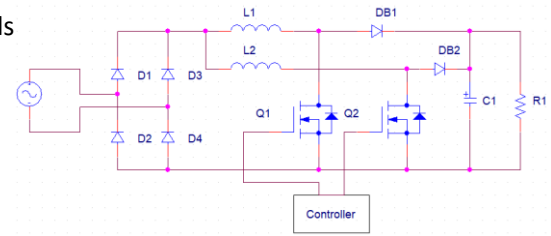


# OBC – AC/DC Converter + PFC

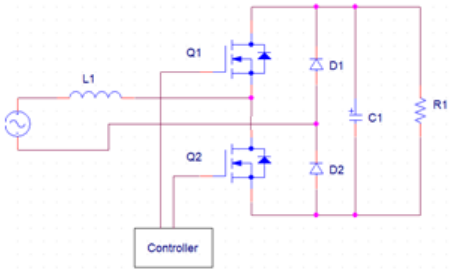
### Interleaved Boost PFC

- Two independent PFC channels
- Reduces input/output ripple
- Efficiency >96%
- Doubles the frequency
- Smaller filters
- Can work DCM or CRM



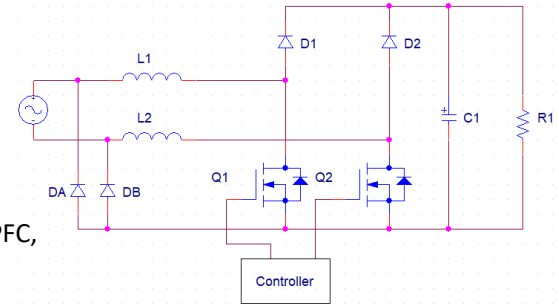

### Totem Pole PFC

- Less components
- Q1, Q2: SiC or GaN
- D1, D2: low speed
- Lower losses
- CCM mode
- >98% efficiency



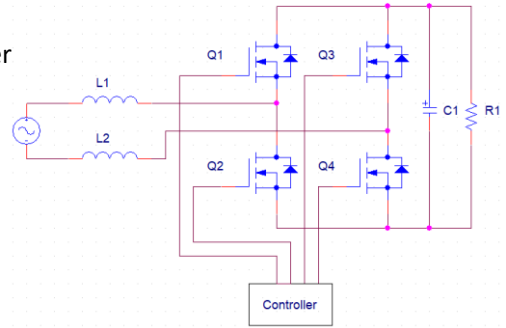

### Bridgeless Boost PFC

- Less components
- Q1, Q2 D1 and D2 work on semi-sin
- 50% losses
- 98% efficiency
- Compared to Conventional PFC, 1 diode drop less




### Full Bridge Totem Pole PFC

- No diodes, lower cross over distortion
- >98% efficiency
- CCM mode
- 4 HV switched, working in PWM
- Bidirectional



# OBC – AC/DC Converter + PFC

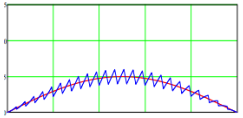
**PFC inductor selection**

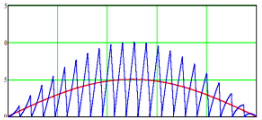
- It is a very important part to the PFC circuit operation
- Prevent saturation
- Constantly provide good power factor
- Inductor value determined by max inductor current ripple

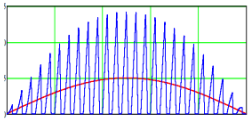
- Address loss optimization
  - Balance between core and copper loss

- CCM:
  - Usually larger filter than CrCM or DCM
  - Full load inductor current ripple less than half the average

- CrCM:
  - Inductor current ripple more than twice the average
  - Higher Core Loss
  - Higher Winding Loss
  - Stable Value (inductor is part of the “timing”)

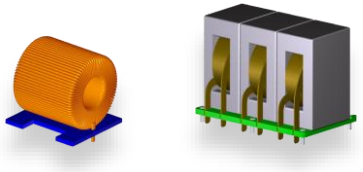

Continuous Conduction Mode (CCM)


Critical Conduction Mode (CrCM)


Discontinuous Conduction Mode (DCM)

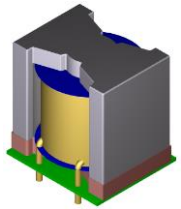
**Bourns PFC Inductors**

- -40°C to 130°C
- 3,5kW-7,0kW
- 50-100kHz
- $I_{SAT}$ up to 45 A
- 90-400µH



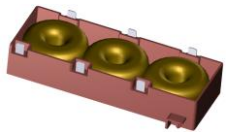
**One Phases PFC**

- Package: 37x3x40 mm
- 2,4kW OBC
- 60uH ±10%
- DCR: 40mΩ
- $I_{RATED}$: 28A



**Three Phases PFC**

- Package: 115x55x25mm
- 11KW OBC
- 120uH
- DCR: 35mΩ
- $I_{RATED}$: 25A



# OBC – DC/DC Converter

## LLC Converter

- DC input voltage from PFC (+100Hz AC ripple)
- DC output isolated voltage to HV battery

- H bridge: generates a square pulse waveform

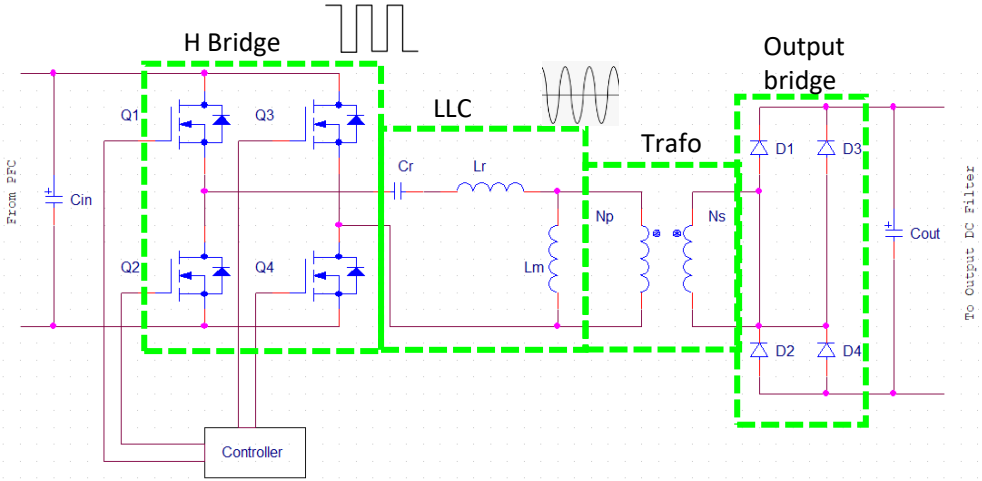
- **Lr: resonant inductor**
- **Cr: resonant capacitor**
- **Lm: magnetizing inductance of the isolation transformer**

- LLC: Square waveform → almost-sinusoidal

- Isolation transformer:
  - Galvanic isolation input/output
  - Block conductive EMI noise
  - Protect primary from load short circuit

- Ns/Np
  - nominal input and output voltages

- Lr/Lm: typ 1:3 to 1:7



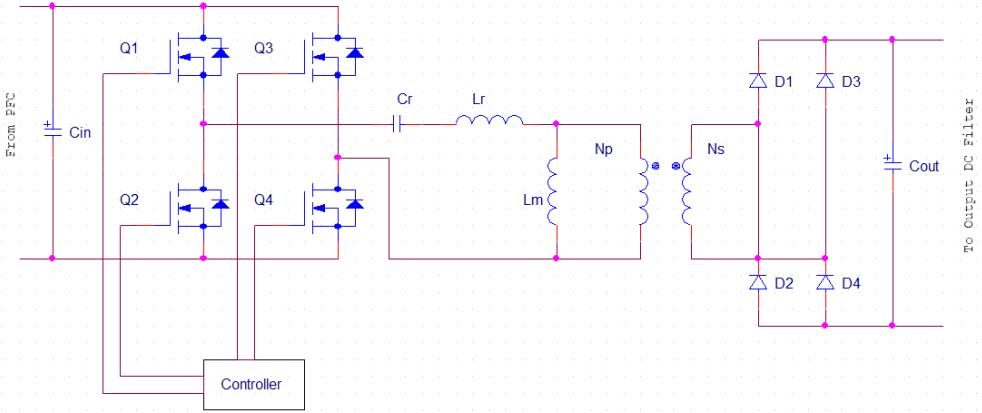

- $f_{SWITCH} < f_{RESONANCE}$ → higher current in the resonant tank, higher conduction losses

- $f_{SWITCH} > f_{RESONANCE}$ → higher switching losses

- $f_{SWITCH} = f_{RESONANCE}$ → best working efficiency

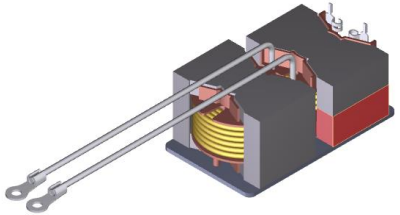
# OBC – DC/DC Converter

## LLC Converter



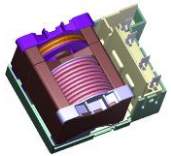

**Integrated Resonant Inductor + Main transformer**

- Package: 86x50x35mm
- 3.6KW LLC design
- Reinforced insulation 4.25KVrms
- Leakage inductance 20uH Max
- Total power loss < 45W
- PQ50/33.5+PQ50/30 Example



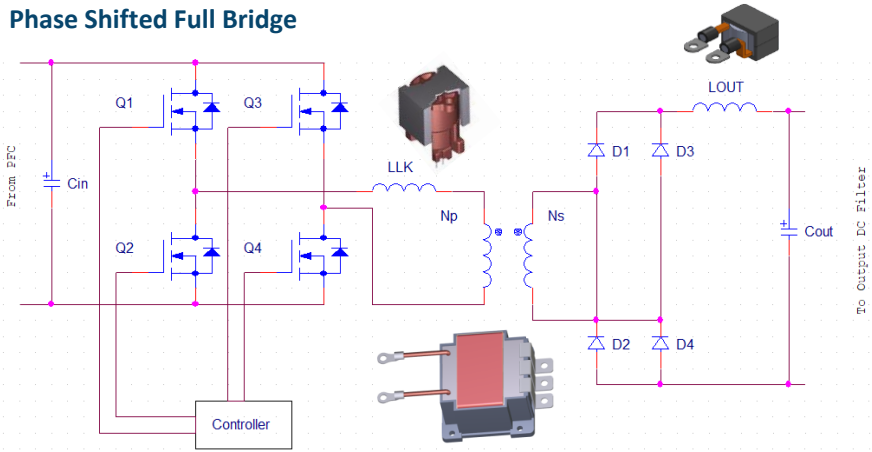
**Integrated Resonant Inductor + Main transformer**

- Package: 94.3*68*47.1mm
- 3.6KW LLC design
- Reinforced insulation
- 5.1KVrms isolation
- CP: 150PF Max
- Total power loss < 30W
- PQ50/45+PQ50/30 Example



# OBC – DC/DC Converter

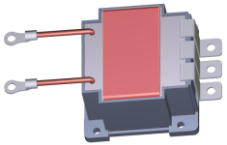
**Phase Shifted Full Bridge**




**Bourns DC-DC transformers**

- Operation temperature –40°C to +130°C
- Power is up to 3.0 kW
- Reinforced insulation
- Shift phase full bridge topology design
- Frequency range 80 – 100 kHz
- Integrated transformer and filter inductor solution

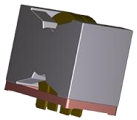
**Main Transformer**



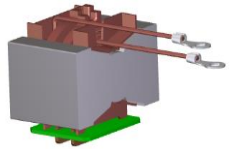
- Package: 80*67*35mm
- Power: 2.5KW
- Reinforced insulation
- 3.6KVrms isolation
- ER52 Example
- Turn Ratio: 1:1:18

**Bourns DC-DC Output Filters**

- Operation temperature –40°C to +130°
- High power planar output filtering choke
- Frequency 200 kHz
- 1.0 µH – 3.0 µH
- Ipeak = 250 Arms max / Is = 180 Arms
- Total power loss <20 W



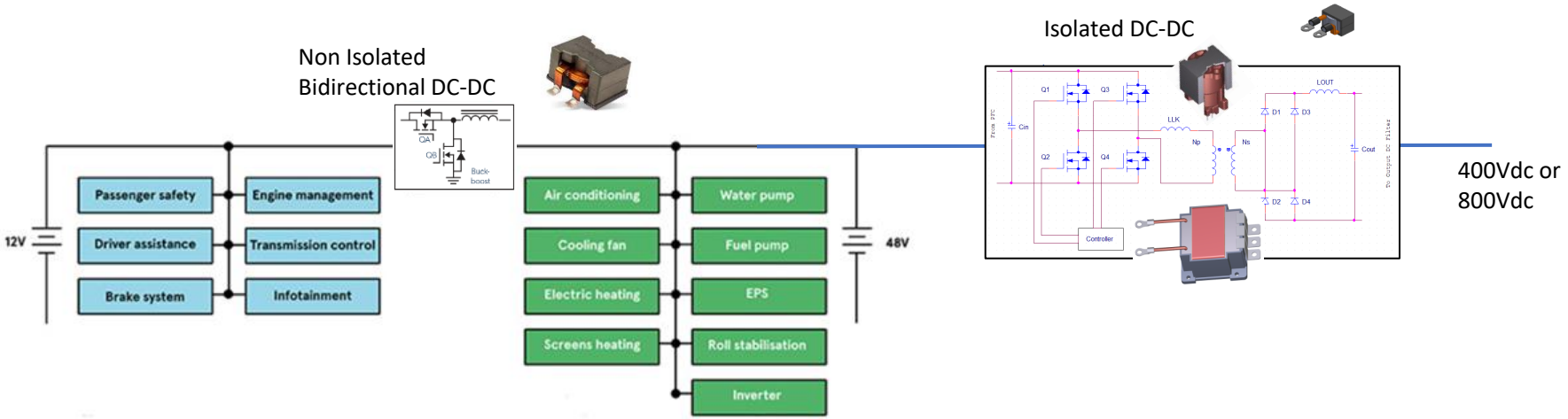
**Main transformer**



- Package: 80*67*35mm
- Power: 2.0KW
- Reinforced insulation
- 3.6KVrms isolation
- PQ50/32 Example
- Turn Ratio: 1:1:12

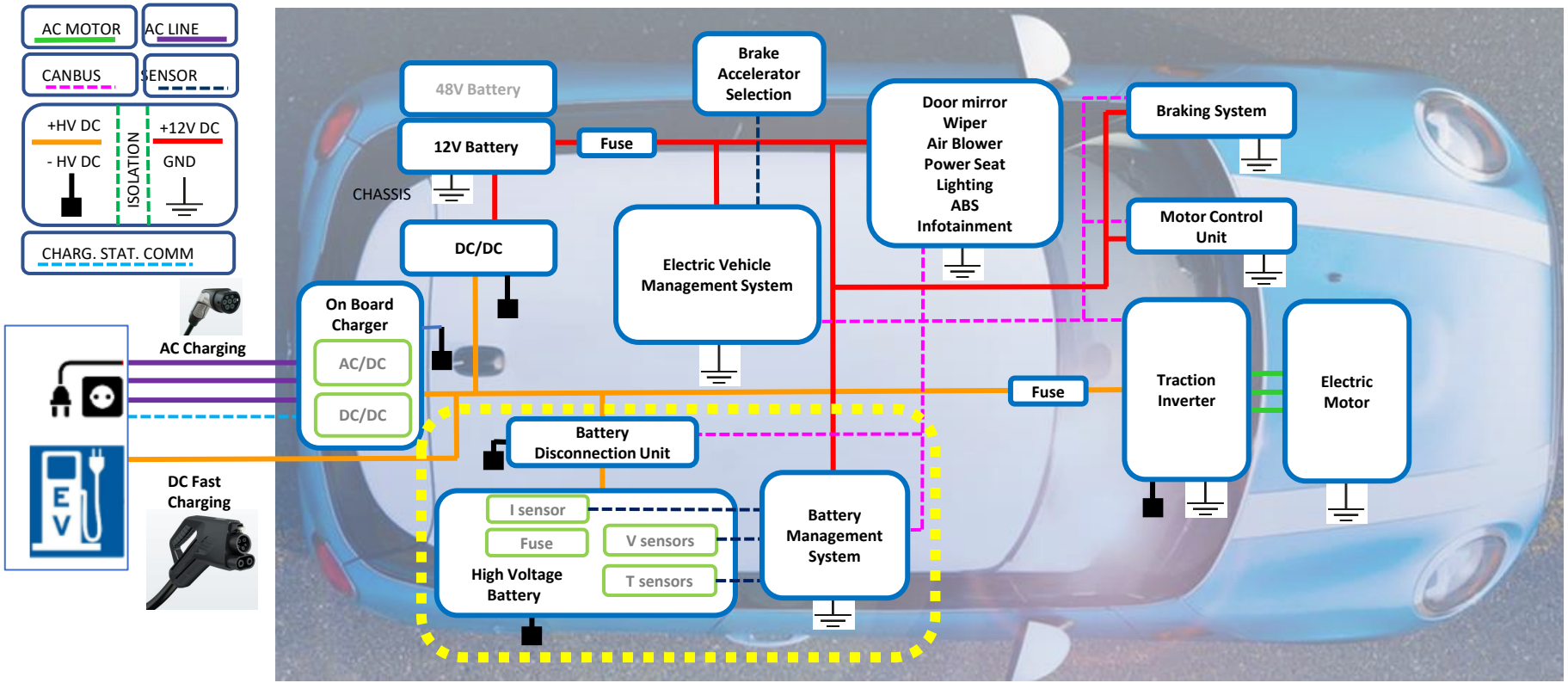
# DC/DC Converter HV to 12V or 48V

- Internal Combustion Engine Vehicles: +12V electrical system
- Electric Vehicles: several components not belt-driven, but electrically driven (water pumps, power steering pumps, fans, HVAC)
- Many of this motor pump require high level of power (~kW) → high current at 12V → expensive cabling
- Gradual transition to 48V for these devices
- Infotainment, ECUs, etc remains 12V

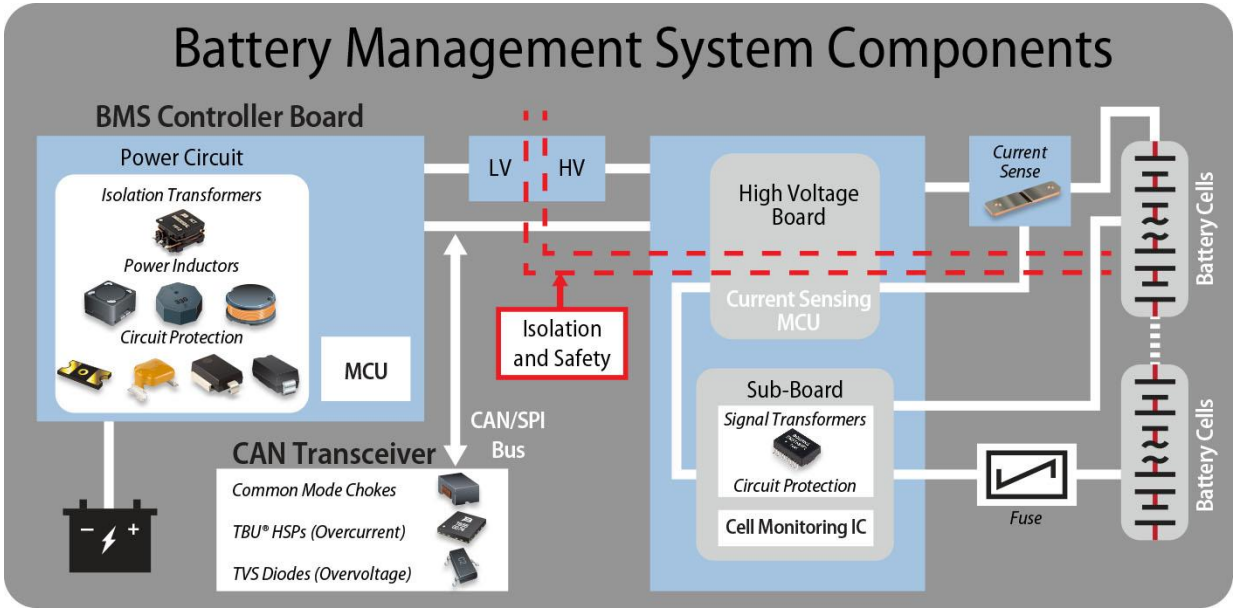


# Magnetics in EV Battery Management Systems

# EV architecture

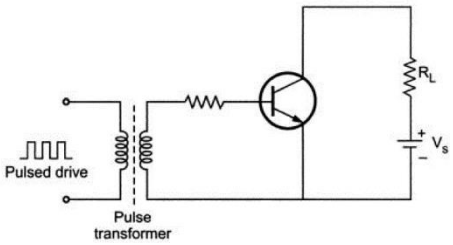


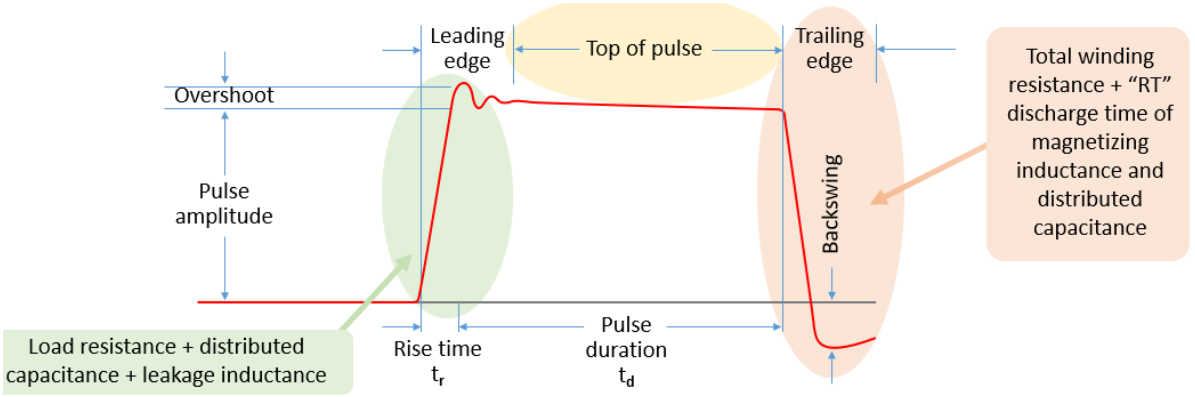
# Bourns Components for BMS




- Signal level
  - BMS-SPI interface cells monitoring communication
  - CANBUS filters
  - CANBUS transformers
- Power level
  - Flyback power supply
  - DC-DC isolated auxiliary power
  - EMI/EMC Filters

# Signal integrity



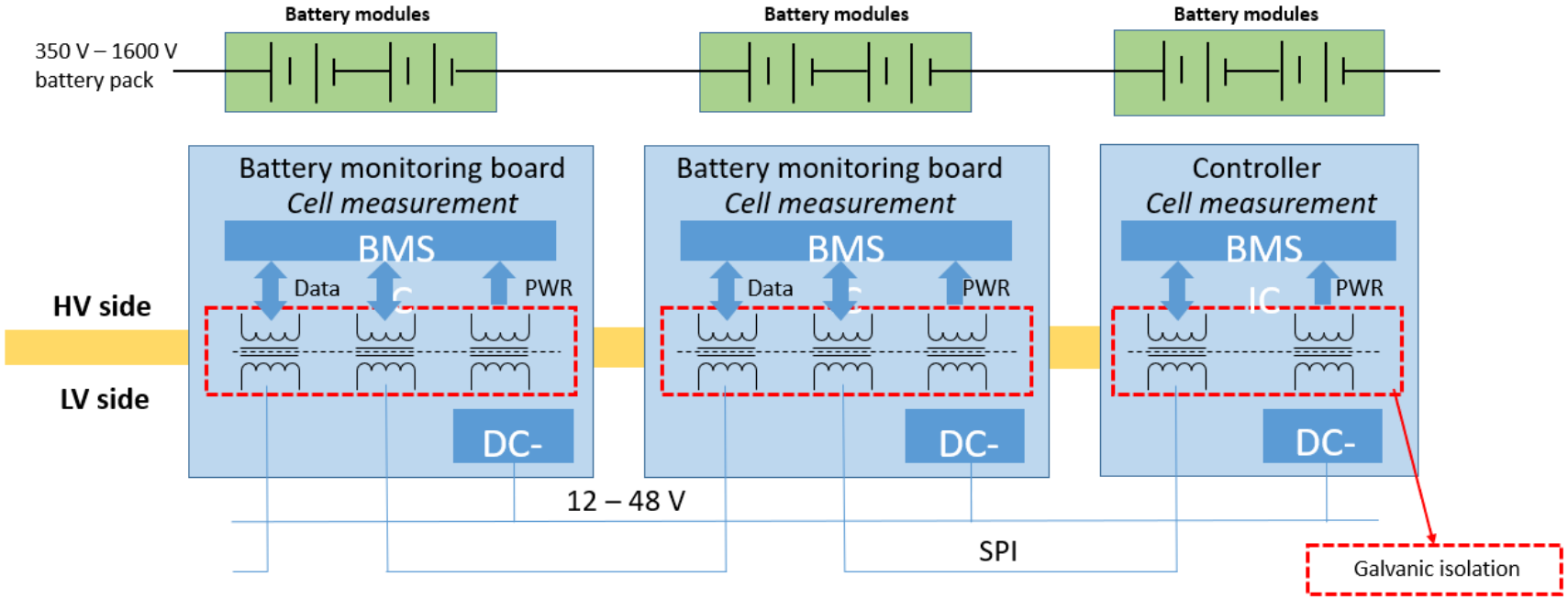




Signal integrity for a categorized pulse transformer essentially means the transformer must provide a level of circuit isolation but at the same time be "invisible" to the signal waveform.

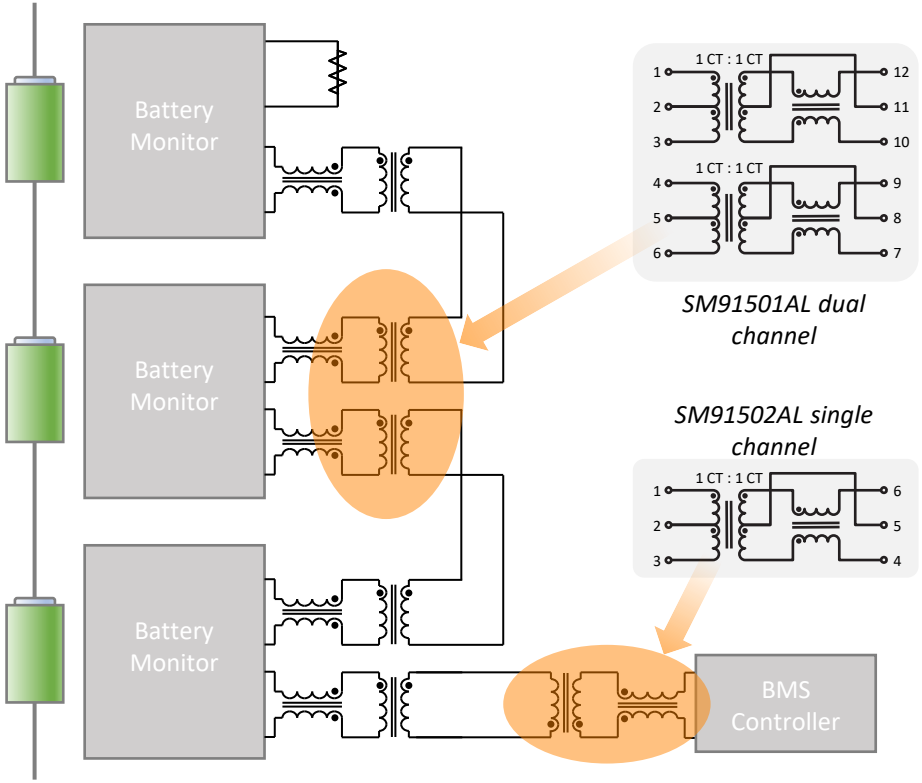
Magnetizing inductance must be sufficient to translate the leading edge and top of waveform pulse while injecting a little parasitic components as possible.

# Isolation Requirements

High Voltage Isolation in BMS - Isolation for reliable communication and power conversion between high voltage battery monitoring modules and the main controller



# Isolation Transformers for BMS-SPI Interface




### SM91501AL Dual Channel Isolation Transformer

- Transformer + choke
- Temperature range: –40 °C to +125 °C
- Inductance: 150 µH ~ 450 µH
- Functional insulation
- Working voltage: 1600 VDC
- Hi-Pot: 4300 VDC or 3100 VAC
- Dual channel
- AEC-Q200 compliant

### SM91502AL Single Channel Isolation Transformer

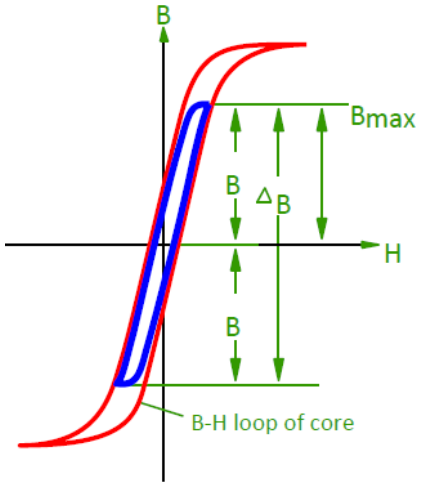
- Transformer + choke
- Temperature range: –40 °C to +125 °C
- Inductance: 150 µH ~ 450 µH
- Functional insulation
- Working voltage: 1000 VDC
- Hi-Pot: 4300 VDC
- Single channel
- AEC-Q200 compliant

*Approved for LTC6804 , LTC6811 by ADI and MC33771/33772 (NXP)

# Isolated Power Conversion Drivers - Topology

**Push-Pull**

- Transformer (bipolar)

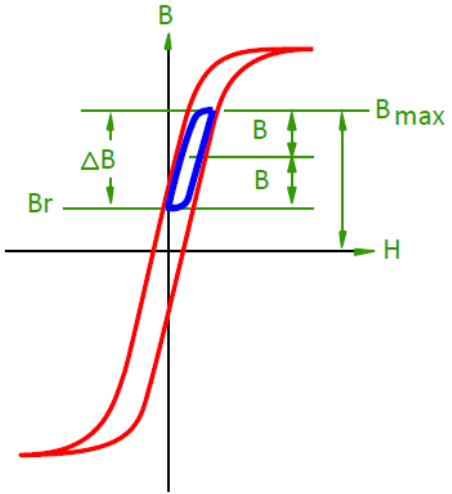



## Magnetics Design and Implementation

| | | |
|---|---|---|
| + | Material utilization | – |
| N/A | Magnetizing flux | N/A |
| + | EMI performance | – |
| N/A | Transformer size (smaller) | N/A |
| + | Leakage inductance | – |
| + | Gapped core | – |
| – | Switch timing | + |
| – | Voltage range | + |
| – | Interwinding capacitance | – |
| – | Safety | – |

**Flyback (any)**

- Inductor
- Transformer (unipolar)



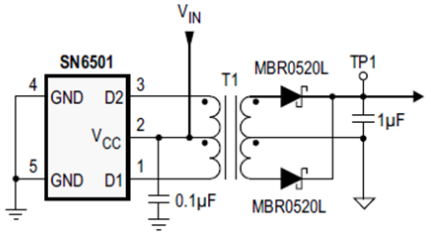
# Push-Pull Transformer – HCT


## Features

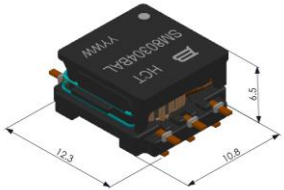
- Low profile (6.5 mm) housing with >8 mm clearance and creepage
- Complies with IEC 60950-1, IEC 62368-1 and IEC 60664-1
- Reinforced insulation for working voltage of 800 V
- Designed for isolation power supplies using TI SN6501 and SN6505B isolation transformer drivers
- AEC-Q200 compliant
- RoHS compliant**

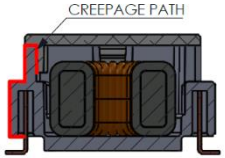
## Applications

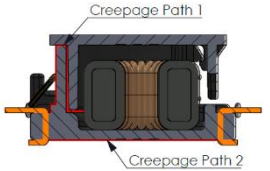
- RS-485
- CAN Interface
- Digital Input Modules
- RS-232 Isolation



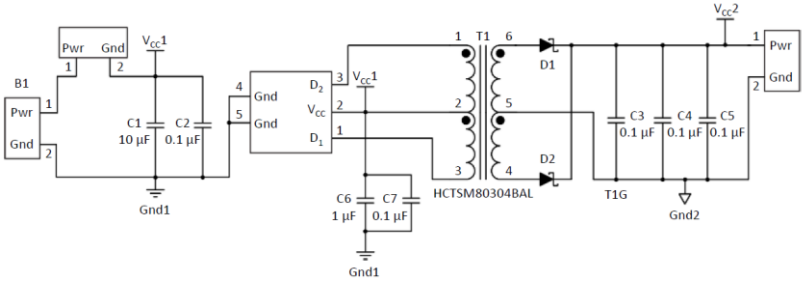

Push Pull Power Converter with TISN6501



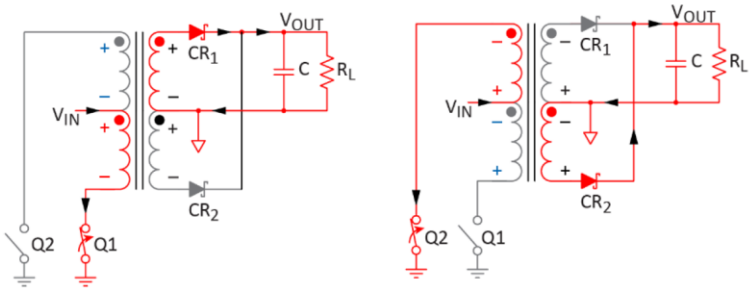



# Push-Pull configuration



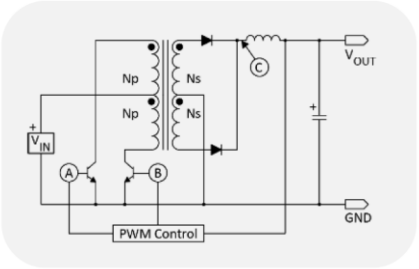

## Push-Pull Operation

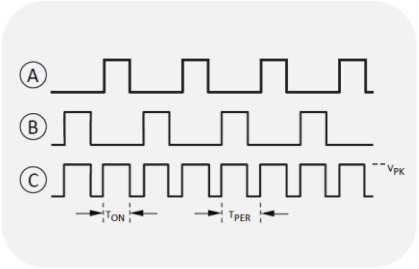
Switching cycles of a push-pull converter



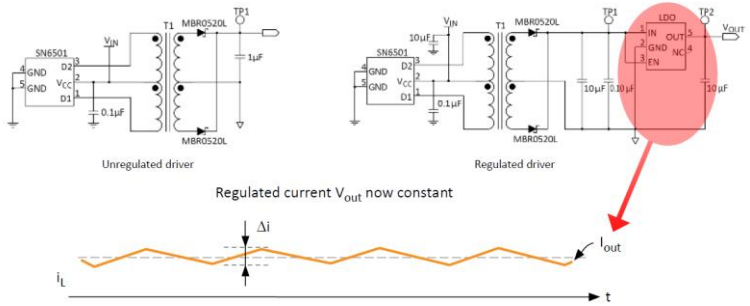

## Push-Pull Timing

Input /output waveforms of push-pull drivers



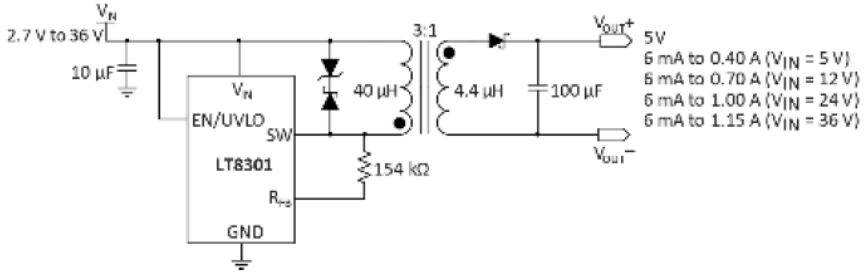



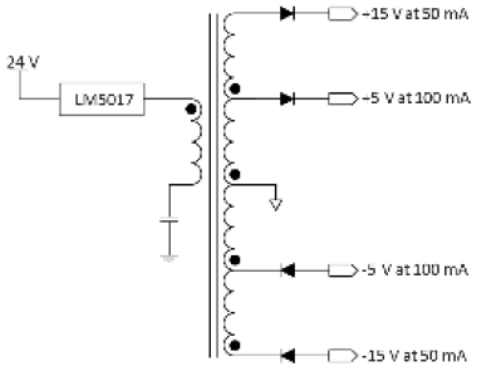

## Example – TI SN6501 Evaluation Board

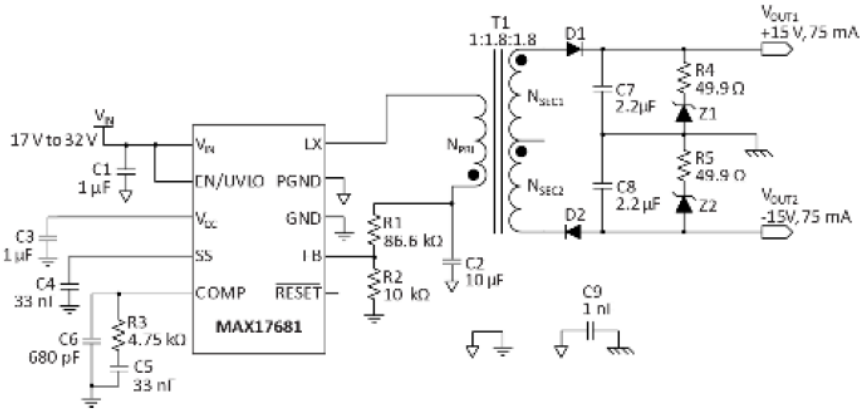


# Low Power DC-DC Flyback Applications

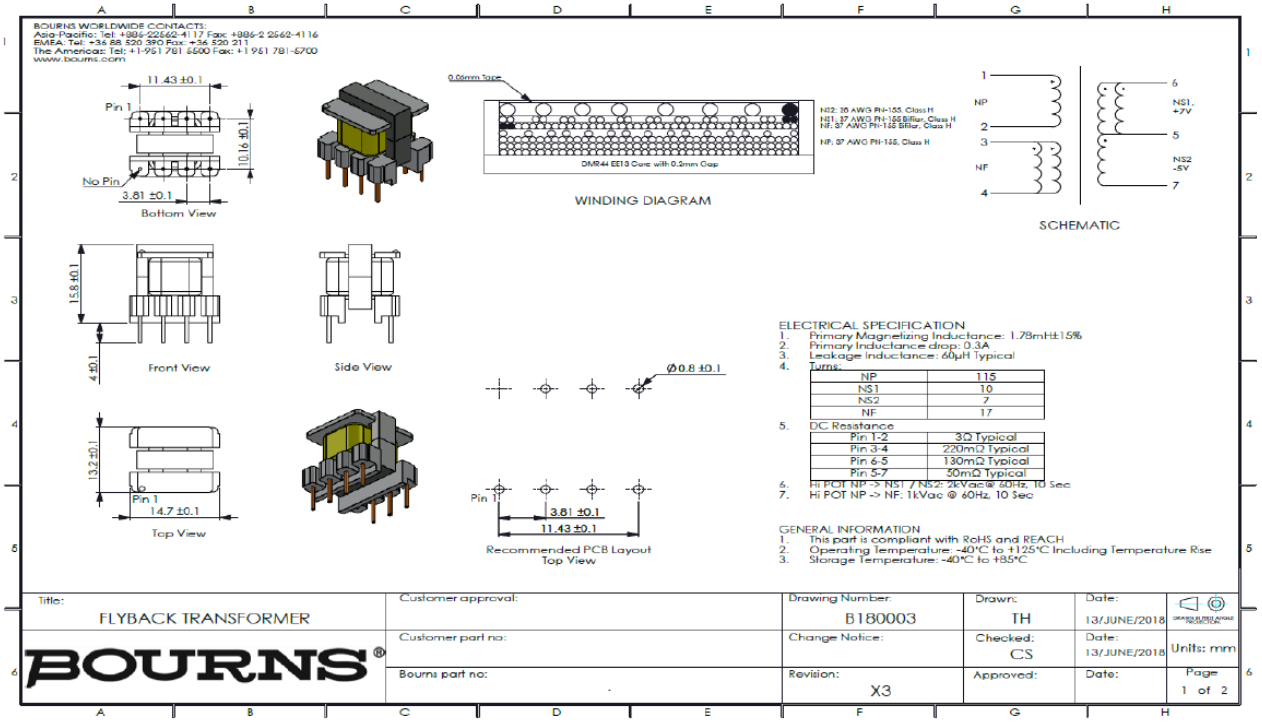
- TI Flyback (LM5017)
- MAXIM ISO-BUCK (MAX17681)
- ADI Micro Power (LT8301)



# Flyback Custom Design



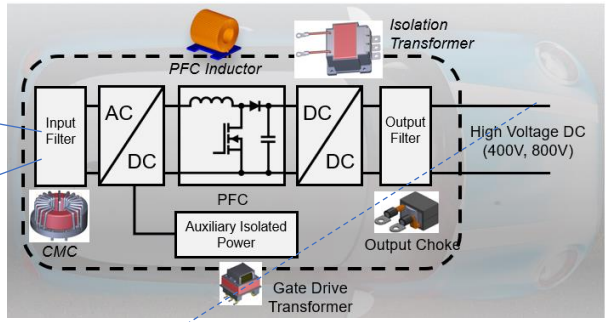
# Magnetics in EV charging stations

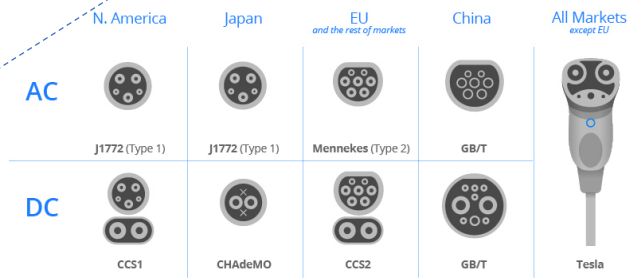
# EV charging stations Methods

**AC charging station, level 1**
*Single phase 120/230Vac*
*12-20A, <4kW;*
*Standard wall power outlet*

**AC charging station, level 2**
*Single phase / Three phase*
*230/400Vac, <20kW;*
*Dedicated EVSE**

**DC charging station, level 3 Fast chargers**
*200-920Vdc up to 240kW*
*Dedicated EVSE**



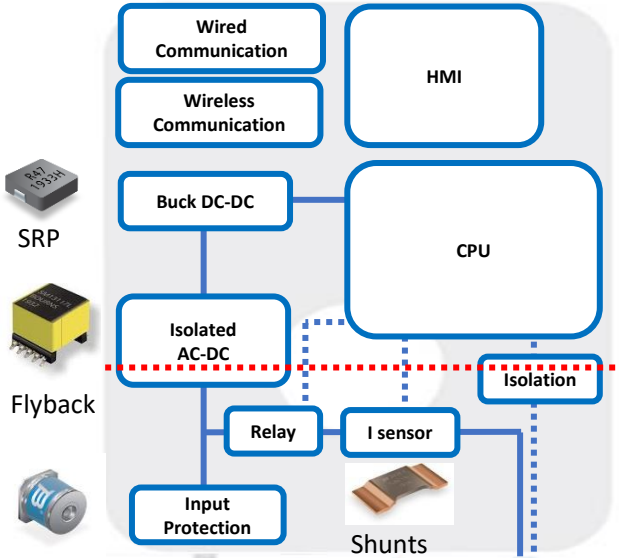




**EVSE: Electric Vehicle Supply Equipment*

# AC Charging Station

## Level 1&2 EVSE

- EVSE is just a monitors device
  - Controls AC voltage path from the grid to the vehicle
  - Acts like an energy meter
  - Charge rate is determined by vehicle's OBC
  - Pilot line via ±12V PWM
  - Handshaking for safety





SRP


Flyback


SM91502AL


GDT, IsoMOV, Fuse


Shunts


Current transformer

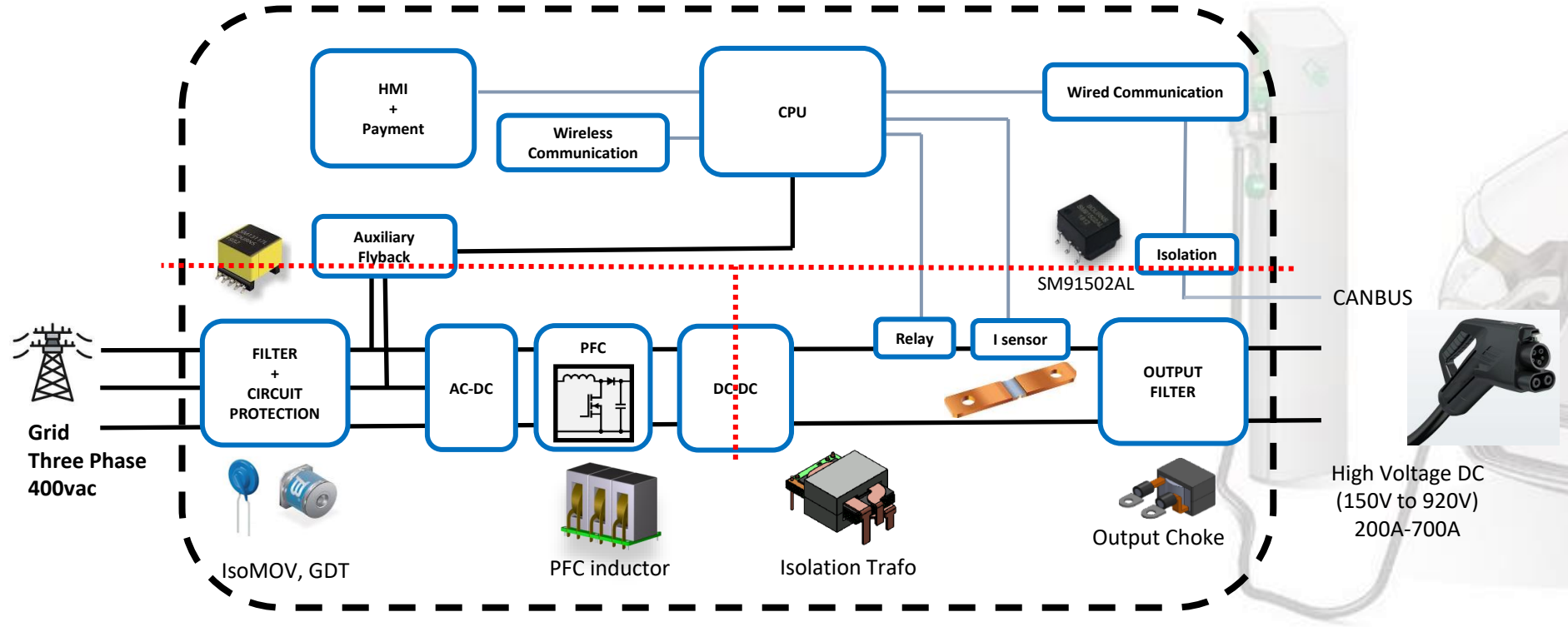
AC line

Pilot line

**Grid**
**Single Phase 220Vac**
**Three Phase 400vac**
**12- 40A**

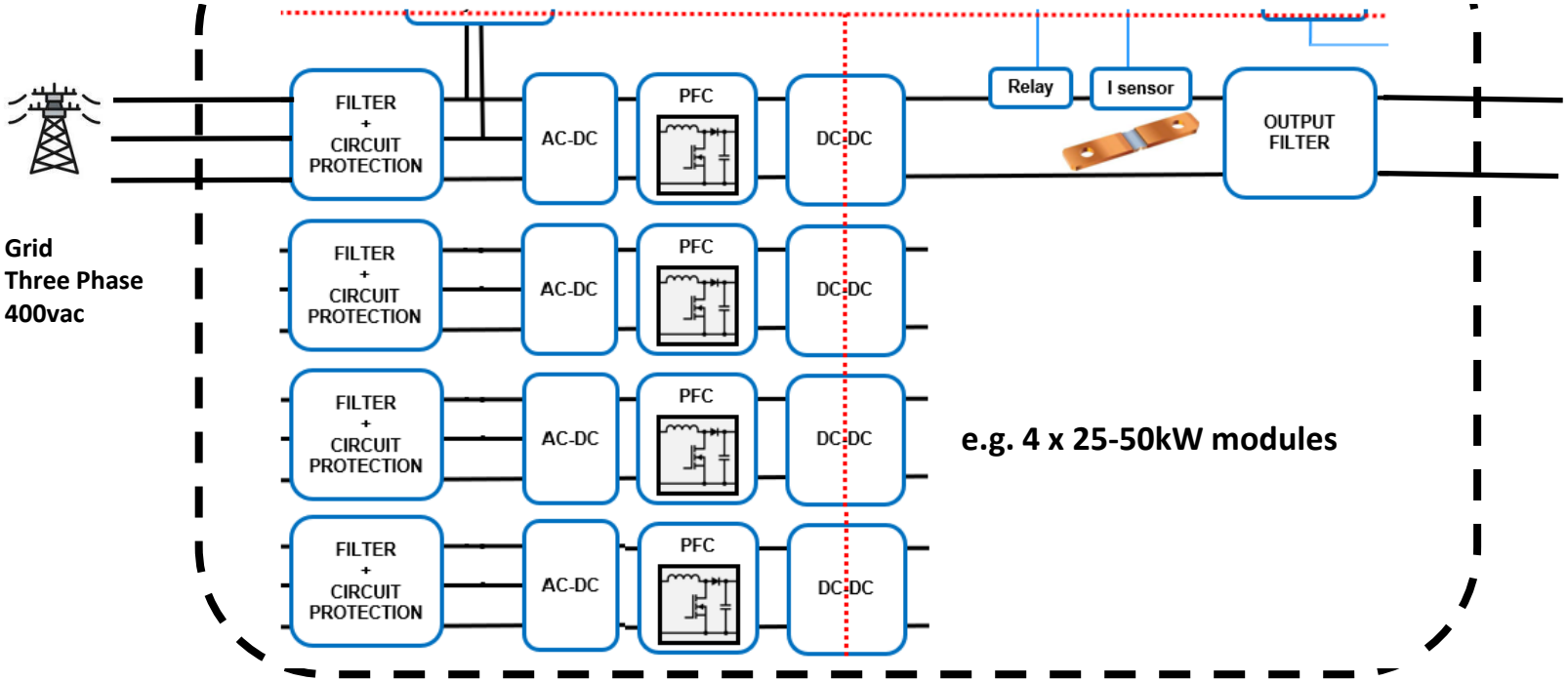
# DC Charging Station

## Level 3 EVSE



# DC Charging Station

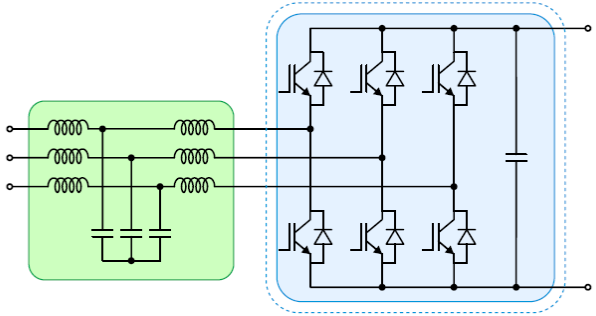
## Level 3 EVSE – Multiple parallel modules




High Voltage DC
(150V to 920V)
200A-700A

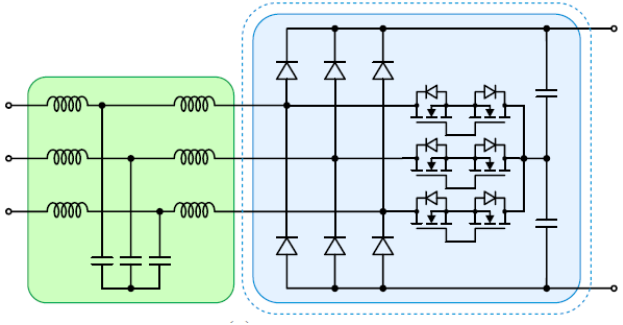
# DC Charging Station – AC/DC Converter

**Three-phase Active PWM with LCL filter**



- Bidirectional AC-DC
- Boost-type converter
- Low harmonics
- PF regulation

**Vienna Rectifier**

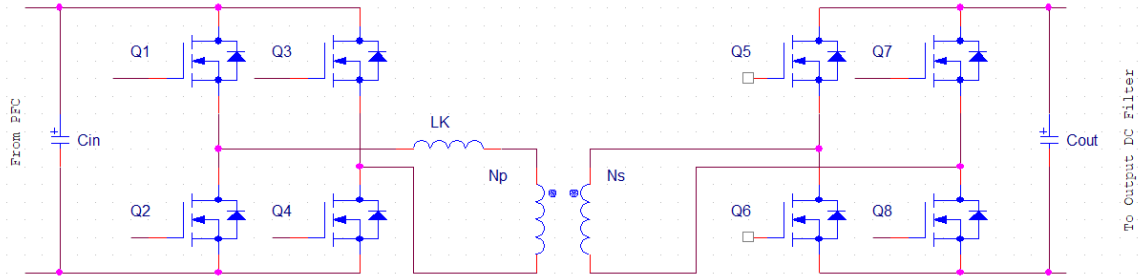


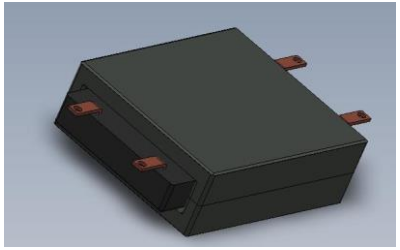
- Unidirectional AC-DC
- Limited reactive power control
- Low Harmonics

# DC Charging Station – DC/DC Converter

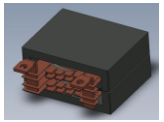
**Dual Active Bridge**

- Series inductor $L_K$ (soft switching)
- Isolation Transformer
- $N_P$:$N_S$ base on $V_{IN}$:$V_{OUT}$



Solution: planar transformer 30kW
Max Primary Voltage 500V
Max Secondary Voltage 500V
Current RMS: 130A
Current Peak: 210A
Switching Frequency: 70KHz



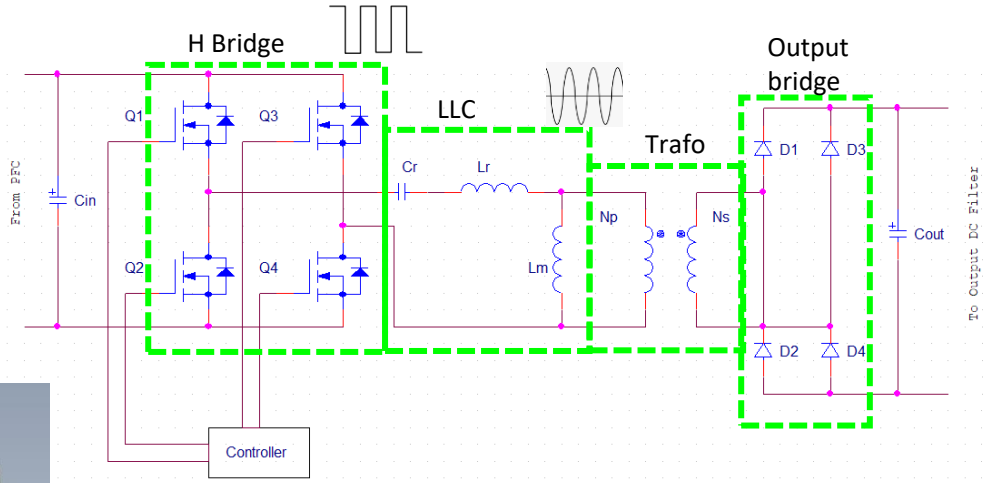
Solution: Inductor 6µH
Current RMS: 130A
Current Peak: 210A
Switching Frequency: 70KHz
Max Magnetic Flux: 2.5mV*s

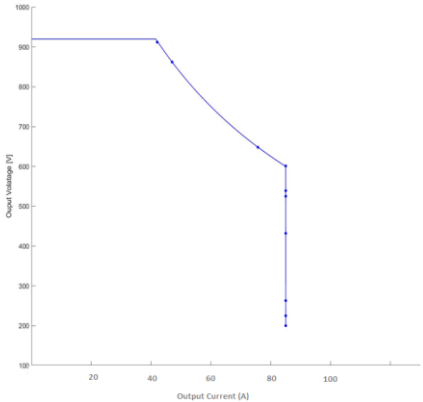
Planar magnetics are used in the design of high-frequency power converters due to its advantages, like low profile, excellent thermal characteristics or power density.

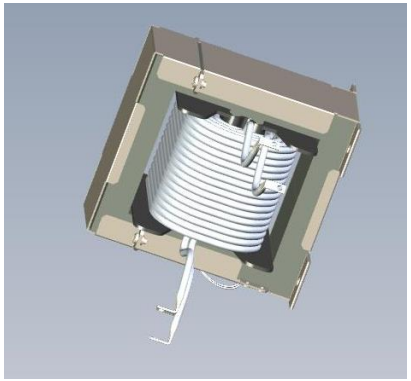
# DC Charging Station – DC/DC Converter

## LLC Converter

- Resonant converter
- Single capacitor placed in series with the primary of the transformer and from the dispersed inductance (Lr series resonance) and the magnetizing inductance (parallel resonance Lm)



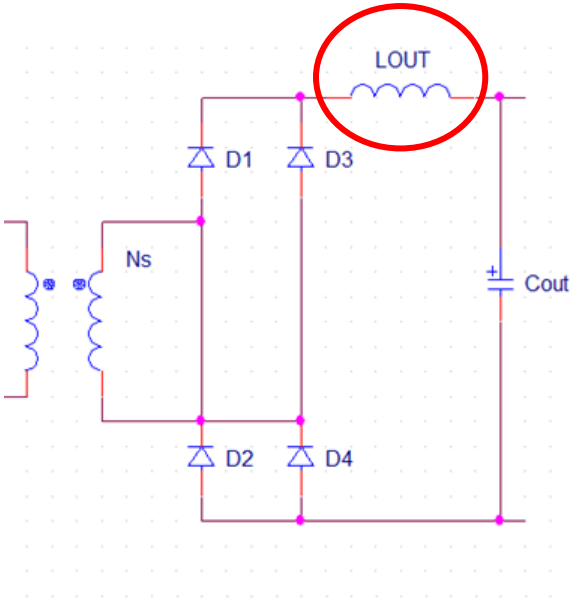



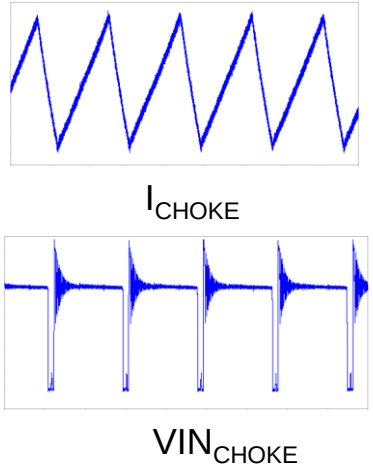



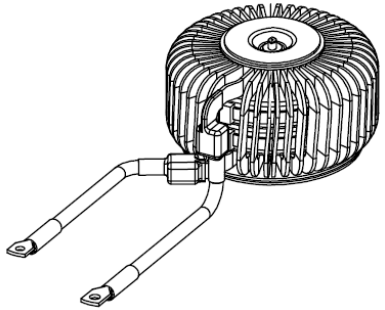
Solution: transformer 50kW
Max Primary Voltage 600-1000V
Max Primary Current: 90A
Max Primary Voltage 600-1000V
Max Primary Current: 90A
Switching Frequency: 50KHz
Primary Leakage Inductance: 7µH
Magnetizing Inductance: 70µH

# DC Charging Station – DC Choke

DC bus choke limits the peak value of the line current, which mitigates harmonics transmitted



| | | |
|---|---|---|
| Maximum RMS current | 90A | |
| Maximum peak current | 11A | |
| Maximum voltage | | 1000V |
| Maximum DC resistance | 6mΩ | |
| Minimum inductance | 140μH | |

Dimension: 120mm diam, 55mm height

# Bourns Power and Signal Catalog Components

# Power and Signal Magnetic Components

- Broad portfolio of catalog Power and Signal Magnetic Components
- Portfolio matches increasingly complex and demanding application needs
- Portfolio makes it easy to select the right components for any application
- Strong technology roadmap, continuous new product releases
  - *40 new series introduced in 2020*
  - *>20 new series introduced in 2021 YTD*
  - *AEC-Q200 compliant components*
  - *Designed to support high current, high frequency, high temperature, low DCR, low core loss, small size requirements*
- Multiple reference designs with global IC manufacturers
- Agency standards compliance
- Large and growing portfolio of automotive grade parts
- Platinum Level Supplier Excellence Award recipient


AUTOMOTIVE GRADE

# Bourns® Magnetics Components

- Transformers
  - LAN
    - Chip Lan
    - Traditional
  - Power
  - BMS
- SMD Inductors
  - Common Mode Inductors
    - Power
      - SRF Series
    - Signal Line
      - Sector W. Bifilar W.
        - DR331 DR221
  - Chip Inductors
    - Multilayer
      - Ferrite
        - Standard CS Series
      - Ceramic
        - Standard CI Series
    - Wirewound
      - Open CW Series
      - Sealed CM Series
  - Power inductors
    - Non-Shielded
      - SDE Series SDR Series
    - Semi-Shielded
      - SRN Series
    - Shielded
      - SRR Series SRU Series
    - High Current
      - SRP Series PQ Series
- Through-hole
  - Standard
    - Axial Series
    - Radial Series
  - High Current
    - Axial Series
    - Radial Series
    - Toroid Series
    - Common Mode Series

# Power Inductors: Non-shielded, Semi-shielded, Shielded and High Current Shielded

| Inductor Model | SDE / SDR<br>Non-shielded | SRN<br>Semi-shielded | SRR / SRU<br>Shielded | SRP<br>High Current Shielded |
|---|---|---|---|---|
| **Appearance** |  |  |  |  |
| **Features** | • Ferrite core<br>• Low cost<br>• High saturation current | • Ferrite core<br>• Semi-Shielded with epoxy resin<br>• Lower radiation than non-shielded<br>• Lower cost than shielded | • Ferrite core<br>• Shielded<br>• Low radiation<br>• Low DCR | • Alloy powder core<br>• Shielded<br>• Low radiation<br>• Low DCR<br>• High rated current |
| **Models Available** | 24 | 28 | 64 | 83 |
| **Footprint** | 3 x 3 to<br>22 x 22 mm | 2.6 x 1.6 to<br>10 x 10 mm | 2.8 x 2.8 to<br>18 x 18 mm | 2 x 1.6 to<br>23 x 23 mm |
| **Height** | 2.5 to 7 mm | 1 to 6 mm | 0.9 to 6.5 mm | 1 to 7 mm |
| **Inductance** | 0.8 to 15,000 µH | 0.47 to 470 µH | 0.47 to 15,000 µH | 0.1 to 100 µH |
| **Rated Current** | 0.02 to 16 A | 0.28 to 10 A | 0.02 to 20 A | 1.2 to 55 A |

# Transformers - Power / Signal / BMS / Chip LAN

| Inductor Model | BS6 – HCT – SM Power | SM Signal | SM915xx BMS | SM Chip LAN (Discrete & Module) |
|---|---|---|---|---|
| **Appearance** |  |  |  |  |
| **Features** | • Various input / output voltage<br>• High isolation voltage<br>• High clearance/ creepage distance<br>• Design to meet IEC | • Toroid core<br>• IEEE 802.3 Ethernet compatible<br>• PoE / PoE+<br>• Built-in common mode chokes<br>• +125 °C operating temp. available | • Toroid core<br>• One or two-channel<br>• High isolation voltage<br>• High working voltage<br>• Built-in common mode chokes<br>• High temperature +125 °C | • Ferrite drum core / ferrite plate cap<br>• Shielded construction<br>• IEEE 802.3 Ethernet compatible<br>• PoE / PoE+<br>Discrete:<br>• Flexible PCB layout<br>Module:<br>• Pin-to-pin compatible to traditional LAN transformer<br>• Built-in common mode chokes<br>• Metal shield |
| **Models Available** | 4 | 14 | 7 | 5 (Discrete) + 5 (Module) |
| **Footprint** | 10.5 x 9.8 to 17.8 x 13.5 mm | 12.8 x 9.3 to 24.2 x 18.2 mm | 8.89 x 7.62 to 31.5 x 12.5 mm | 3.5 x 3.2 to 4.7 x 3.22 mm (Discrete)<br>12.7 x 8.67 to 17.03 x 14.6 mm (Module) |
| **Height** | 6.5 to 12.7 mm | 5.65 to 12.8 mm | 5 to 9.5 mm | 2.9 mm (Discrete)<br>4 - 4.5 mm (Module) |
| **Rated Power** | 1.8 – 13 W | N/A | N/A | N/A |
| **Bit Rate** | N/A | 10/100/1000M | N/A | 1 to 10G |

# Common Mode Chokes - Power / Signal

| Inductor Model | DR – SRF Power | SRF Signal |
|---|---|---|
| Appearance |  |  |
| Features | • Ferrite core<br>• Shielded construction<br>• Bifilar and sector wound available | • Ferrite drum core / ferrite plate cap<br>• Shielded construction<br>• Bifilar wound - high common mode impedance |
| Models Available | 14 | 12 |
| Footprint | 5.2 x 5 to 12.5 x 12.6 mm | 2 x 1.2 to 4.5 x 3.2 mm |
| Height | 6.5 to 12.7 mm | 1.2 to 3 mm |
| Impedance | 140 – 10,000 Ω | 30 – 10,000 Ω |
| Rated Current | 0.1 – 8.9 A | 100 – 400 mA |

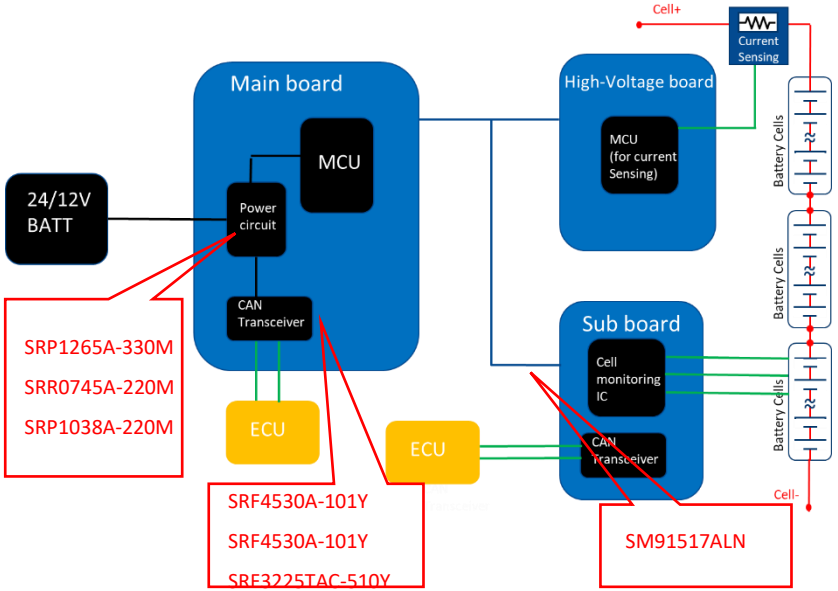
# Reference Designs with Global IC Manufacturers

- Reference designs help customers save time and minimize risk
- Bourns has multiple reference designs with major IC manufacturers

| Year | Semiconductor Company | IC Part Number | Application | Bourns Part Number | Reference |
|---|---|---|---|---|---|
| 2021 | TI | TPA6304-Q1 | Automotive Class D Amplifier | SRP5015T A-20Y | TPA6304-Q1 Evaluation Module |
| 2021 | TI | TPA6304-Q1 | Automotive Class D Amplifier | SRP5015TA-R22Y | TPA6304-Q1 Evaluation Module |
| 2021 | TI | TPA6304-Q1 | Automotive Class D Amplifier | SRP5015TA-R33M | TPA6304-Q1 Evaluation Module |
| 2021 | TI | SN6501-Q1 | Isolated Power Supplies | HCTSM8 | SN6501-Q1 |
| 2021 | ADI | ADBMS6830M | Automotive BMS | SM91501ALE | LTC6812-1 |
| 2021 | ADI | ADBMS682 | Automotive BMS | SM91501ALE | LTC6812-1 |
| 2021 | PI | INN3996CQ | High voltage input automotive isolated DC-DC Power Supply | SRP4020T A-1R5M | DER-889Q Design Example Report |

Look for synergistic sales of ICs and Bourns Magnetics

# Success Story: BMS at CATL



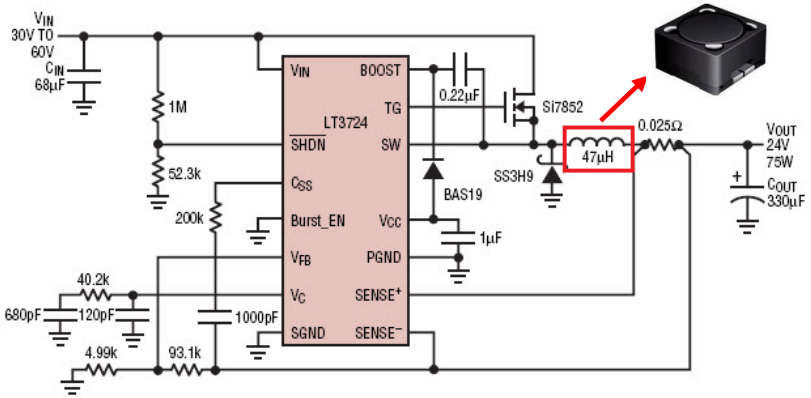

- SRF4530A-101Y
- SRF3225TAC-510Y
- SRP1265A-330M
- SRR0745A-220M
- SRP1038A-220M
- SRF4530A-510Y
- SM91517ALN

## Bourns Power and Signal Magnetic component solutions for BMS

# Success Story: BMS at Rivian

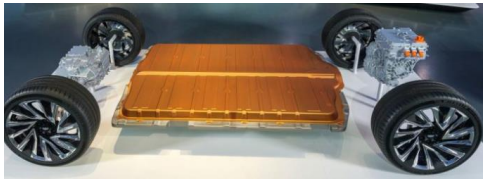
Application: Electric Truck, BMS, DC-DC converter

Bourns P/Ns: SRR6040A-470M, SRP1238A-4R7M

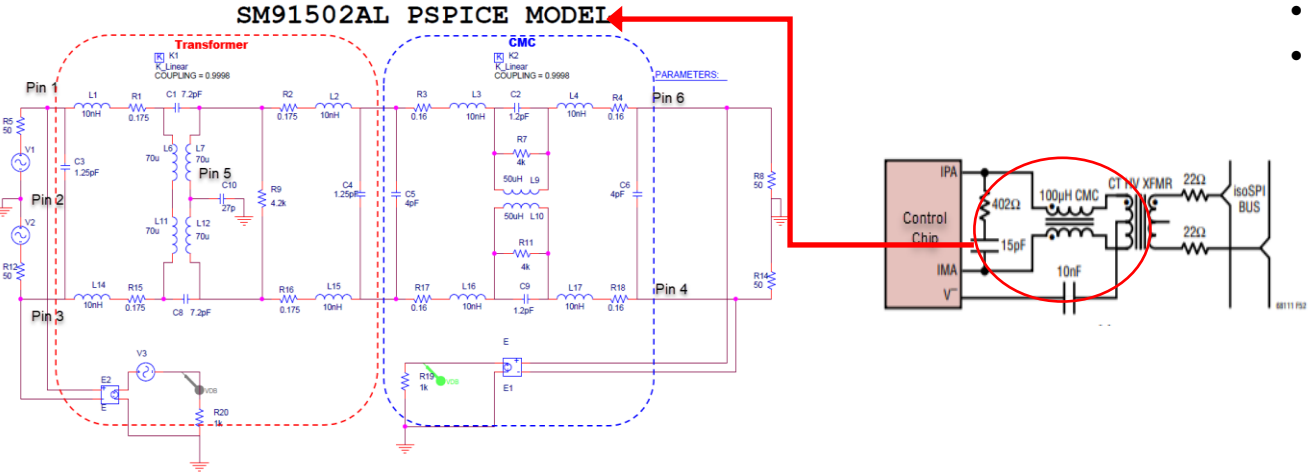



## Bourns Power and Signal Magnetic component solutions for BMS

# Success Story: BMS at Visteon



- Application #1 – SPI Signal Line Transformer
- Application #2 – Redundant “Spy” Network
- Bourns SPI Transformers
  - SM91502ALV (Application #1)
  - SM91502ALV (Application #2)




Bourns Power and Signal Magnetic component solutions for BMS

# RECOMMENDATIONS - OBC

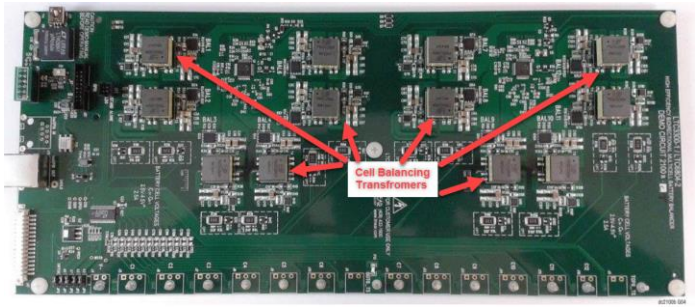
1. Remember Automotive OBC Potentially Routes Power From:
   - DC/DC Single Phase
   - AC/DC Three Phase or Single Phase
   - DC/DC Wireless Receiver

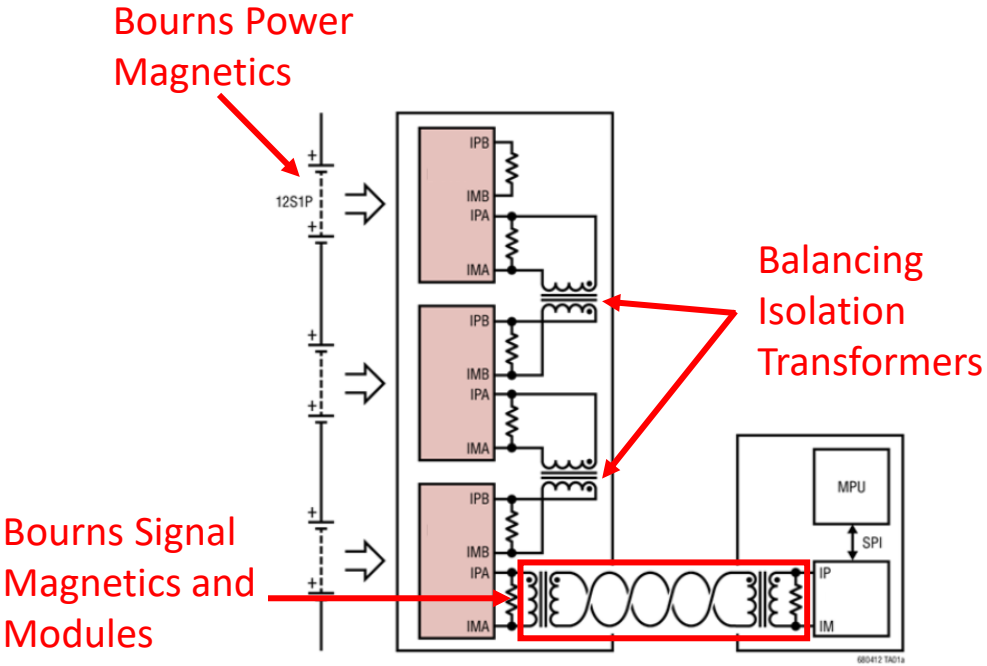
2. Because the Combination of AC – DC – DC Conversion with Both 3 Phase and Single Phase in the Same Application
   - Input EMI Filter – 2 Magnetic Components Potential
   - PFC Stage – 3 Magnetics Components Potential
   - Mains Transformer – 1 Magnetic Component Potential
   - Output Filter – 4 Magnetics Component Potential

**Recommendation is if Encountering One Magnetic Finished Good there is Potential for up to 10+ Total Magnetics Goods to Evaluate on the High-Power Conversion Stage Alone**

# RECOMMENDATIONS - BMS

- Complete BMS Systems May Include
  - *Power Level Magnetics from Presentation*
  - *Signal Level Magnetics from Presentation*
  - **Multi - Cell <u>Daisy Chain</u> Balancing Circuits with Magnetics**
- **Recommendation is to Ask About and Evaluate All**



*Thank you!*

BOURNS®