Powering Business Worldwide

Eaton Electronics Passives For Automotive Applications

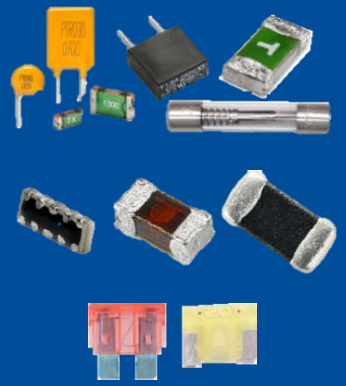
Prepared for Arrow Automotive Group

24Nov2017

Agenda

1. **Eaton ELX AECQ-200 Products**
   - **Magnetics Standard**
   - **Magnetics Custom**
   - **Supercaps**
   - **Circuit Protection**
2. **Automotive Applications Served**
   - **Engine Compartment:** LED Lighting/Powertrain/Electric Grid/Batteries management/HEV Power boost/Engine Start
   - **Passanger Compartment:** Infotainment/Telematics/ADAS/Chargers/Safety

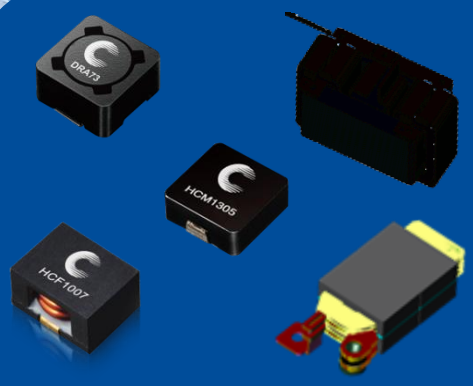
Electronic Automotive Products & Applications



Circuit Protection

Main Applications

- Power Distribution Box
- Infotainment Systems
- Telematics / 4G Communication Units
- Body Electronics
- Spark Ignition
- Antenna Systems



Power Magnetics

Main Applications

- LED Lighting
- Infotainment & Telematics
- Electronic Power Steering
- Engine Control Unit
- Water/Fuel/Oil Pumps
- Advanced Driver Assistance
- Bi-directional DCDC Converter

Supercapacitors & Modules

Main Applications

- Smart Door Latch
- Electronic Power Steering
- Emergency Call Unit
- Hybrid Energy Regeneration
- Engine Start&Stop Battery Boost
- Dynamic Suspension

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R&D – Testing Capabilites

- DNV Certified ISO17025 Test Lab
- Full AECQ Capability
- Complete Part Analysis Capability
- Over 200 Test Equipments

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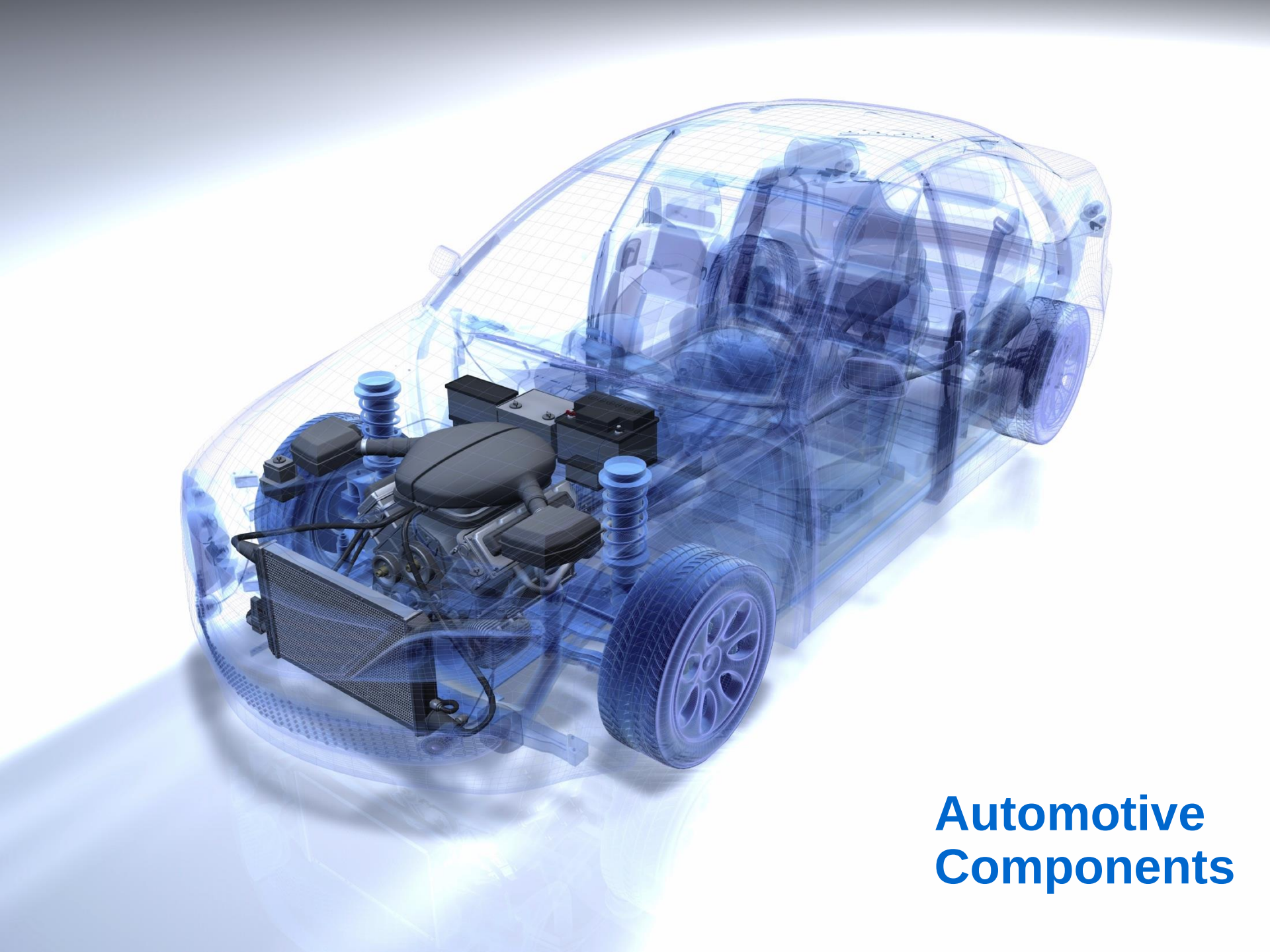
Manufacturing Excellence

- **Strong Focus On Automated Processes**
- **TS16949 Certified Plants In China & Philippines**


Automotive
Components

Magnetics

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Standard AEC-Q200 Qualified Inductors

Part Series	Part Size (mm)	Inductance Range (uH)	AEC-Q Grade
DRA73	7.6x7.6x3.55	0.33-1000	1 - 165C
DRA74	7.6x7.6x4.5	0.33-1000	1 - 165C
DRA124	12.5x12.5x4.5	1-1000	1 - 165C
DRA125	12.5x12.5x6	1.5-1000	1 - 165C
DRA127	12.5x12.5x7.5	2.2-1000	1 - 165C
DRAQ75	7.6x7.6x4.5	15 (10-47 planned)	1 - 165C
DRAQ127	12.5x12.5x7.5	10-47	1 - 165C
HCMA0503	5.5x5.3x3	0.1-22	3 - 125C
HCMA0703	7.3x7x3	0.15-33	3 - 125C
HCMA1104	11x10x4	0.2-10	3 - 125C
HCMA1305	12.5x13.8x5	0.1-33	3 - 125C
HCMA1707	17.2x16.8x7	1.5 - 68	3 - 125C

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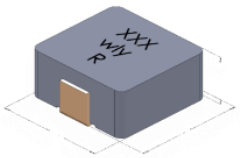
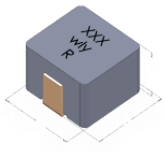
Standard AEC-Q200 Qualified Inductors

Part Series	Part Size (mm)	Inductance Range (uH)	AEC-Q Grade
HCM1A0503	5.5x5.3x3	0.1-10	1 – 155C
HCM1A0703	7.3x7x3	0.15-33	1 – 155C
HCM1A0805	8.3x8.1x5.4	1.5-100	1 – 155C
HCM1A1104	10x10x4	1-47	1 – 155C
HCM1A1305	12.5x13.8x5	0.1-33	1 – 155C
HCM1A1307	12.5x13.8x7	0.47-56	1 – 155C
HCM1A1707	17.2x16.8x7	1.5 - 68	1 – 155C
MPIA40-V2	4.7x4.5x1.2-2	0.1-22	3 – 125C

AEC-Q200 Qualified Inductors – In Works





Part Series	Part Size (mm)	Inductance Range (uH)	AEC-Q Grade	Date Of Qualification
MPIA25-V2	2.5x2x1.2	0.33-4.7	3 – 125C	Q1 2018
HCMA0702R1	7.3x7x2.4	2.2	3 – 125C	Q4 2016
HCM1A0505	5.5x5.3x5	15-22	1 – 155C	Q3 2017
HCM1A0705	7.3x7x3	0.15-33	1 – 155C	Q3 2017
HCM1A1105	11x10x5	4.7-47	1 – 155C	Q4 2017
HCM1A2213	22x22x13	0.47-100	1 – 155C	Q3 2018
HCM1A0805V1	8.3x8.1x5.4	1.5-100	1 – 155C	Q3 2018
HCM1A1104V1	10x10x4	1-47	1 – 155C	Q3 2018
HCM1A1307V1	12.5x13.8x7	0.47-56	1 – 155C	Q4 2018

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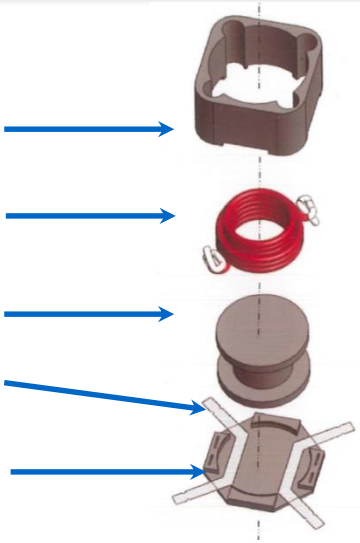
DRA Series

Construction



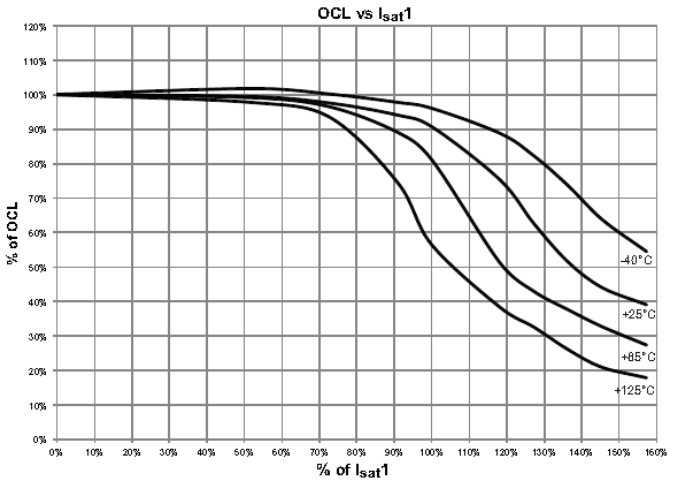
Features/Benefits

- Lowest DCR
- High Isat current
- Enhanced shock&vibration performance
- Optimized for best peak current performance
- 125C ambient / 165C total temp operation

Typical Applications

- LED Lighting
- Powertrain control module (PCU)
- Engine Control unit (ECU)
- Transmission Control Unit (TCU)
- Hybrid electric vehicle (HEV) Inverter controller, Charger

Inductance Rolloff Characteristic



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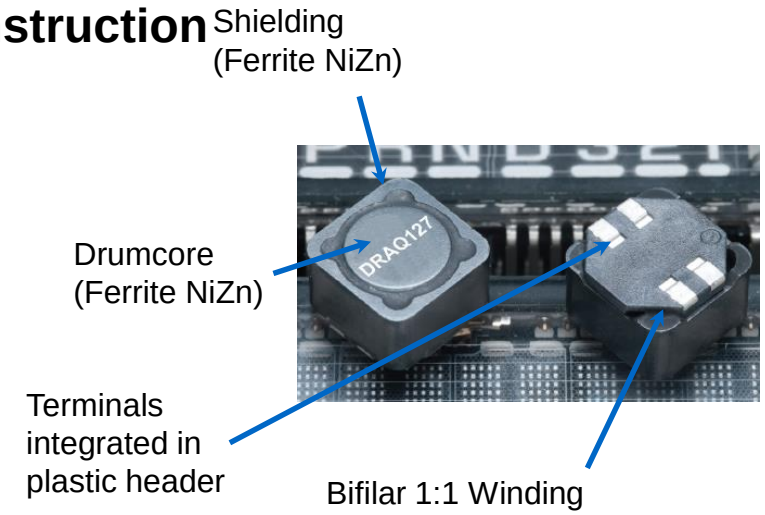
DRAQ Series

Construction



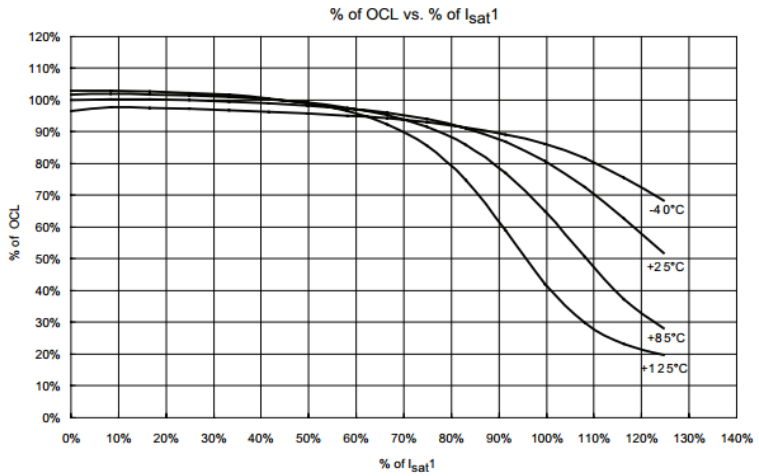
Features/Benefits

- Close coupling between windings
- 200VAC isolation between windings
- Enhanced shock&vibration performance
- Optimized for best peak current performance
- 125C ambient / 165C total temp operation

Typical Applications

- LED DRL
- ADAS
- Infotainment
- Radar power
- Any SEPIC converters

Inductance Rolloff Characteristic



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HCM / MPI Series Cross References

Grade	EATON	Dimensions L x W x H	Würth	Pulse Eng	Bourns	Coilcraft	Sumida	TDK - Epcos
Industrial (125C)	DR1030	10.3 x 10.5 X 3 mm	7447713	NA	NA	NA	CDRH103R	B82464G2
	DR1040	10.3 x 10.5 X 4 mm	NA	PF0560	NA	MSS1038	CDRH104R	NA
	DR1050	10.3 x 10.5 X 5 mm	7447714	NA	NA	MSS1048	CDRH105R	B82464P4
	DR73	7.6 x 7.6 x 3.5 mm	744778	P1166	SRR0603*	NA	CDRH73	B82472G4
	DR74	7.6 x 7.6 x 4.3 mm	744777	P1167	SRR0604*	MSS7341	CDRH74	B82472G6
	DR124	12.3 x 12.3 x 4.5 mm	7447715	P1168	SRR1240	MSS1246	CDRH124	NA
	DR125	12.5 x 12.5 x 6 mm	744771	P1170	SRR1260/1206	MSS1260	CDRH125	B82477P2
	DR127	12.5 x 12.5 x 8 mm	744770	P1172	SRR1280/1208	MSS1278	CDRH127	B82477G4
	DRQ73	7.6 x 7.6 x 3.5 mm	744878	NA	SRF0703	NA	NA	NA
	DRQ74	7.6 x 7.6 x 4.3 mm	744877	NA	NA	MSD7342	NA	NA
	DRQ125	12.5 x 12.5 x 6 mm	744871	PF0552	SRF1260	MSD1260	NA	NA
	DRQ127	12.5 x 12.5 x 8 mm	744870	PF0553	SRF1280	MSD1278	CDRH129B*	NA
AECQ Grade1 (165C)	DRA73	7.6 x 7.6 x 3.5 mm	NA	NA	SRR0735A*	NA	NA	NA
	DRA74	7.6 x 7.6 x 4.3 mm	NA	NA	SRR07030A*	MSS7341T	NA	B82472P6*
	DRA124	12.3 x 12.3 x 4.5 mm	NA	NA	NA	MSS1246T	NA	NA
	DRA125	12.5 x 12.5 x 6 mm	NA	NA	SRR1260A*	MSS1260T	CDRH12D58L*	NA
	DRA127	12.5 x 12.5 x 8 mm	NA	NA	SRR1280A*	MSS1278T	CDRH12D78L*	B82477P4*
	DRAQ75	7.6 x 7.6 x 4.5 mm	NA		SRF0703A*	MSD7342*		
	DRAQ127	12.5 x 12.5 x 8 mm	NA	NA	SRF1280A*	MSD1278T	CDRCH12D78*	B82477D4*

*: similar part, slight difference

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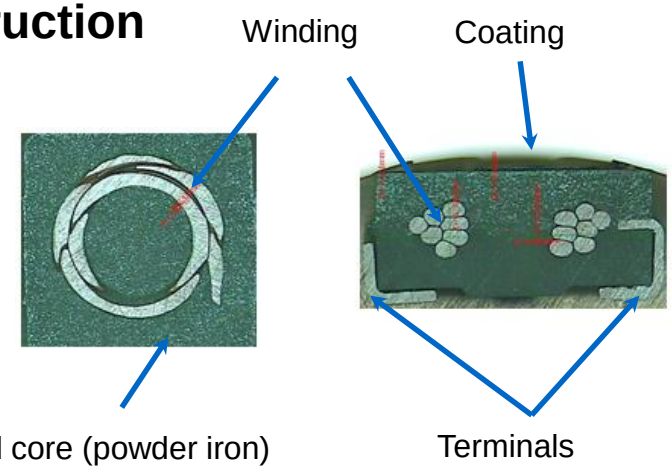
HCM(1)A Series – High Current Molded

Construction



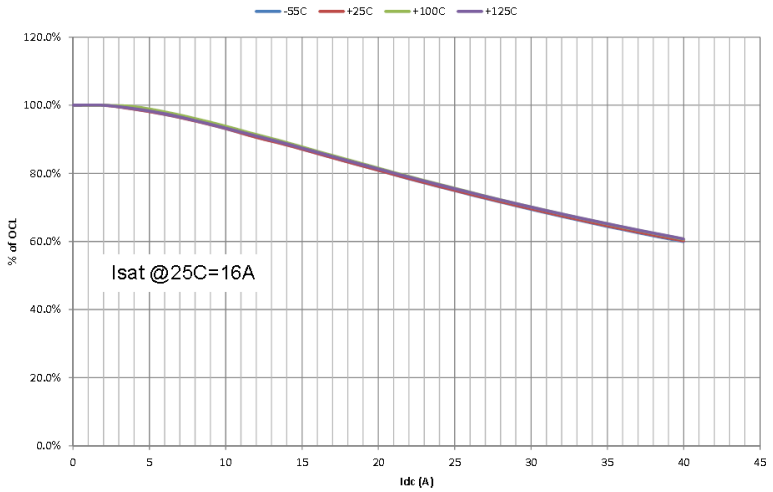
Features/Benefits

- Lower core loss than other powder iron solutions
- Higher Isat
- Lower DCR
- Soft roll-off characteristics
- Magnetically shielded - Reduces EMI
- 155C total temperature
- Fully coated extenally

Typical Applications

- Engine Control Unit – ECU
- Infotainment Systems
- Transmittion Control Unit – TCU
- LED Lighting
- Water, fuel and oil pumps
- Engine cooling fans
- HVAC units

Inductance Rolloff Characteristic



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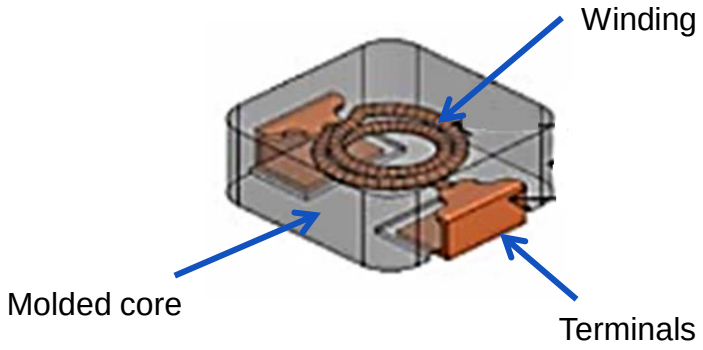
MPIA Series – Miniature Molded Inductor

Construction



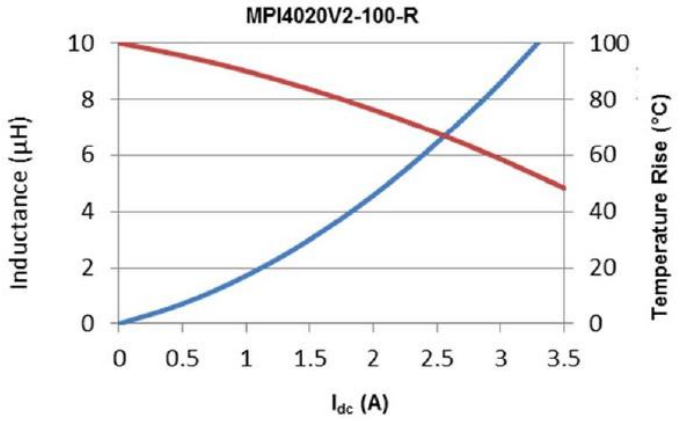
Features/Benefits

- Small footprint 2.7x2.2mm & 4.8x4.5mm
- Low profile 1-2mm
- Flat inductance rolloff versus applied current
- Highest power in smallest package
- Superior EMI shielding
- Lower core losses & higher efficiency performance
- Low losses even above 1MHz switching

Typical Applications

- Vision systems (ADAS)
- Infotainment systems
- Power Port (USB HUB)
- LED Lighting
- Clusters
- Alarm system

Inductance Rolloff Characteristic



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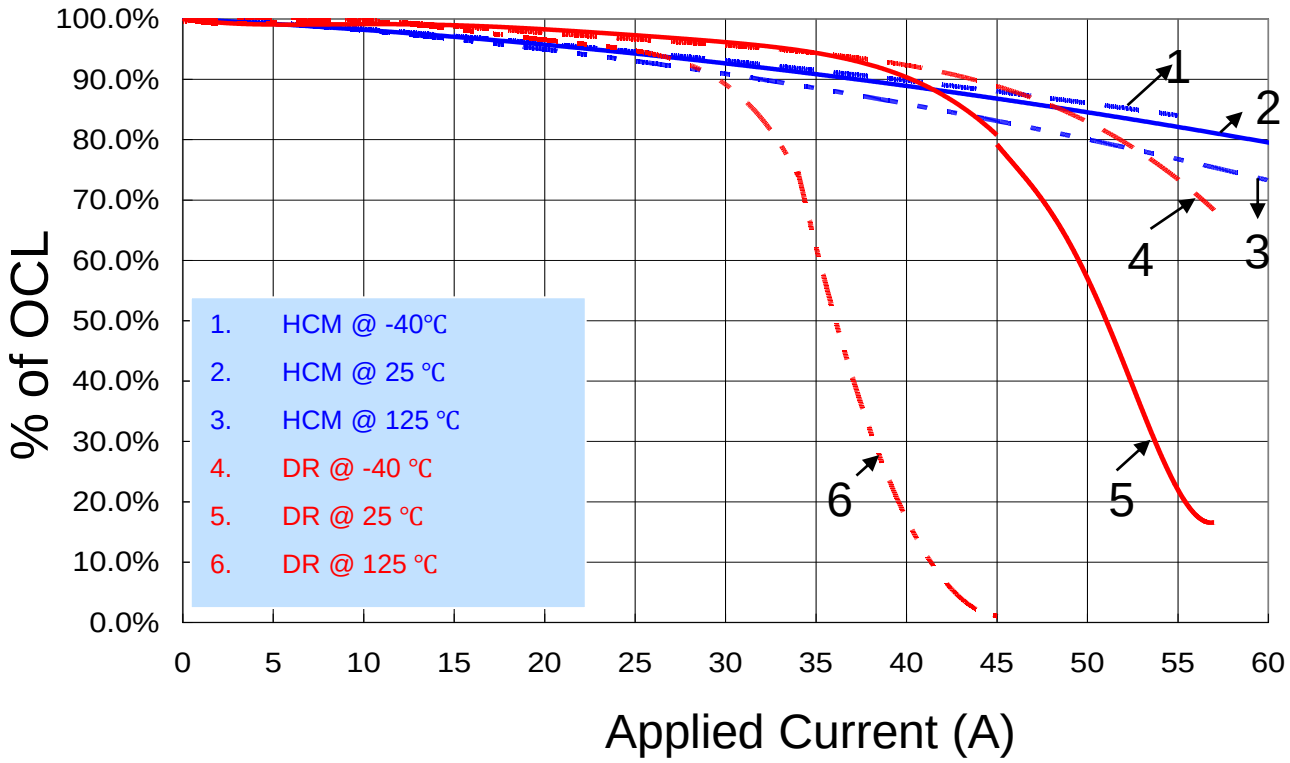
HCMA Inductor Features

HCMA has stable inductance over the complete temperature range => ideal choice for wide temperature range applications required by automotive



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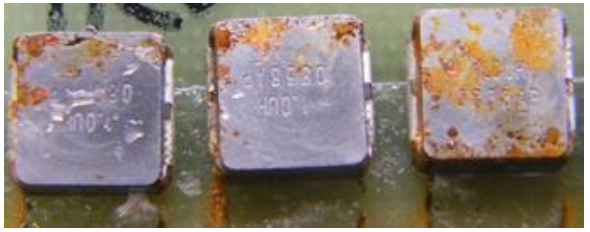
HCMA vs. Competition Comparism

Other performance aspects:

- HCM(1)A is fully covered to protect against corrosion
- HCM(1)A is using low core loss materials, no non-magnetic metal additives used.

HCM with grey coating after subjected to salt-spray test

Competition without antirust protection subjected to salt-spray test



HCM / MPI Series Cross References

Grade	EATON	Dimensions (L X W X H)	Vishay	Würth	Bourns	TDK	Panasonic	Murata/Toko
Industrial (125C)	MPI25xxV2	2.7 x 2.2 x 1-1.2 mm	NA	74438324xxx / 74479287xxx	SRP2512	MLP2520W		DFE25201xC
	MPI40xxV2	4.7 x 4.5 x 1.2-2 mm	IHLP-1616AB-01	744373210xxx/ 744373240xxx	SRP40xx	SPM40xxT		
	HCM0503	5.1 x 5.1 x 3 mm	IHLP-2020CZ-01	744373360xxx	SRP5030T	SPM5030T		
	HCM0703	6.8 x 7.1 x 3 mm	IHLP-2525CZ-01	744373460xxx	SRP7030	SPM6530T	PCC-M730L	
	HCM1103	11 x 10 X 3 mm	NA	NA	NA	NA		
	HCM1104	11 x 10 X 4 mm	IHLP-4040DZ-01	744373680xxx	SRP1040*	NA	PCC-M1040L	
	HCM1105	11 x 10 x 5 mm	NA	NA	NA	NA		
	HCM1305	13.3 x 12.2 x 5 mm	IHLP-5050EZ-01	74437377xxx	SRP1250	NA		
	HCM1307	13.3 x 12.2 x 6.5 mm	IHLP-5050FD-01	7443739650xxx	SRP1265	NA		
	HCM1707	17 x 17 X 7 mm	IHLP-6767GZ-11	NA	NA	NA		
AECQ-200 G3 (125C)	MPIA25xxV2	2.7 x 2.2 x 1-1.2 mm	NA	NA	SRP251xA	TFM252012		
	MPIA40xxV2	4.7 x 4.5 x 1.2-2 mm	IHLP-1616xx-1A	NA	SRP40xxTA	NA		
	HCMA0503	5.1 x 5.1 x 3 mm	IHLP-2020CZ-1A	NA	SRP5030TA	NA		
	HCMA0703	6.8 x 7.1 x 3 mm	IHLP-2525CZ-1A	831 530 xxx	SRP07028A	NA		DFEG7030D
	HCMA1104	11 x 10 x 4 mm	IHLP-4040DZ-1A	NA	SRP1038A	NA		DFEG10040D
	HCMA1105	11 x 10 x 5 mm	NA	831 651 xxx	NA	NA		
	HCMA1305	13.3 x 12.2 x 5 mm	IHLP-5050EZ-A1	831 750 xxx	SRP1245A	NA		DFEG12060D
	HCMA1307	13.3 x 12.2 x 6.5 mm	IHLP-5050FD-A1	NA	SRP1265A	NA		
	HCMA1707	17 x 17 X 7 mm	IHLP-6767GZ-1A	NA	SRP1770TA	NA		
AECQ-200 G1 (155C)	HCM1A0503	5.1 x 5.1 x 3 mm	IHLP-2020CZ-5A	NA	NA	NA	ETQP3 YFP	
	HCM1A0703	6.8 x 7.1 x 3 mm	IHLP-2525CZ-5A	NA	NA	NA	ETQP3 YFN	DFEH7030D
	HCM1A0805	8.1x8.5x5.4mm	IHLP3232DZ-5A	NA	NA	NA	ETQP5 YFK	
	HCM1A1104	11 x 10 X 4 mm	IHLP-4040DZ-5A				ETQP5 YFC	DFEH10040D
	HCM1A1305	13.3 x 12.2 x 5 mm	IHLP-5050EZ-5A	NA	NA	NA		
	HCM1A1307	13.3 x 12.2 x 6.5 mm	IHLP-5050FD-5A	NA	NA	NA	M1280MF	DFEH12060D
	HCM1A1707	17 x 17 X 7 mm	IHLP-6767GZ-5A	NA	NA	NA		
	HCM1A2213	22 x 22 x 13 mm	IHLP-8787MZ-5A	NA	NA	NA		

*: similar part, slight difference

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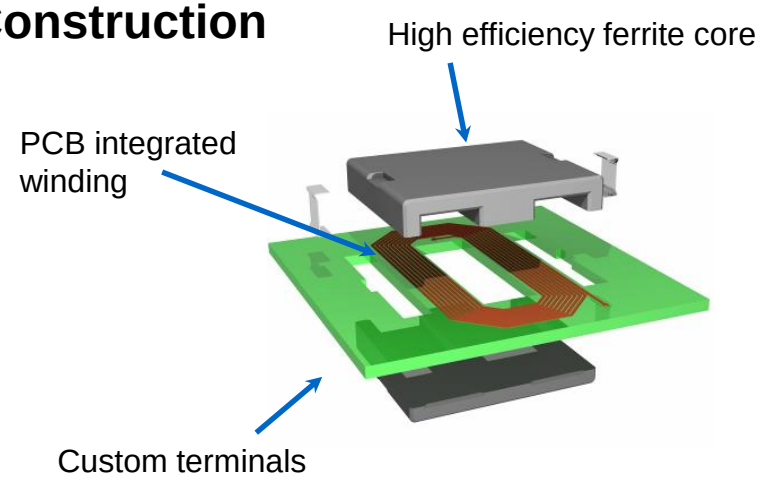
Planar Inductors & Transformers

Construction



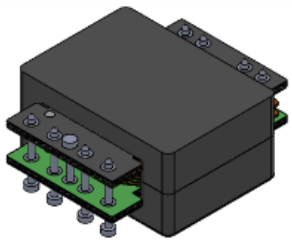
Features/Benefits

- Very high current rating possible (100+A)
- High efficiency with low DCR&ACR
- Easy to optimize gapped core structure

Typical Applications

- High power hybrid drives
- Bidirectional voltage converters
- Electric power steering
- Powertrain

Examples:



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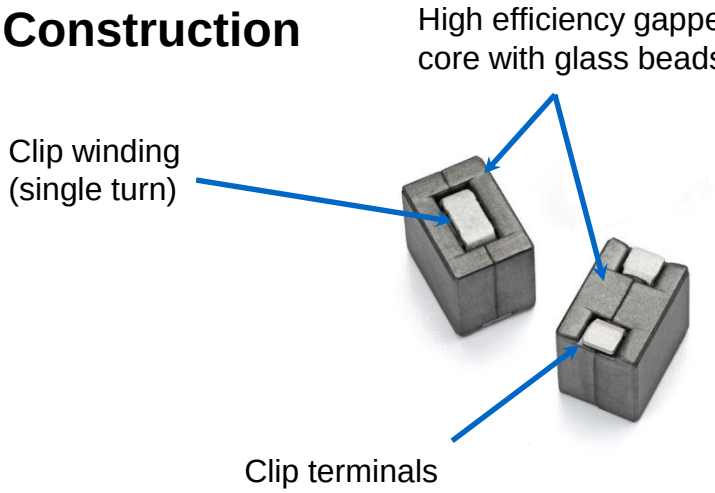
Automotive FlatPac™

Construction



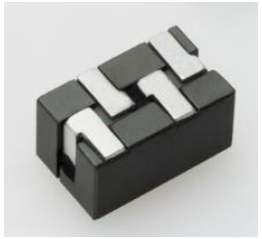
Features/Benefits

- Ultra low DCR using clip technology (micro Ohm range possible)
- High efficiency core
- Up to 1uH possible
- Dual and coupled construction as well
- 100A+ capability in cost efficient form

Typical Applications

- Bidirectional DC-DC converters
- DC grid stabilizers (start-stop vehicles)
- High current filters (up to 100A)

Examples: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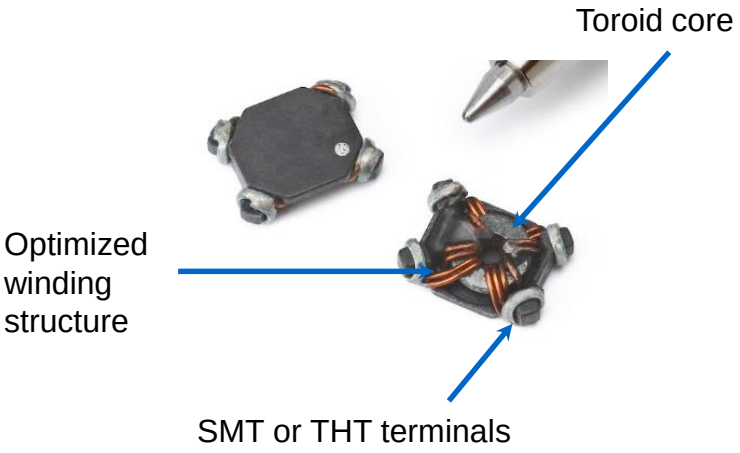
Automotive Common Mode Filters

Construction



Features/Benefits

- Toroid constuction for lowest EMI
- Optimized attenuation rate at given frequency ranges
- Lowest DCR possible by manufacturing
- Up to 100A

Typical Applications

- Electric Power Steering
- Infotainment systems
- LED headlight
- H-bridge drives (cooling fans, fuel pumps)

Examples:

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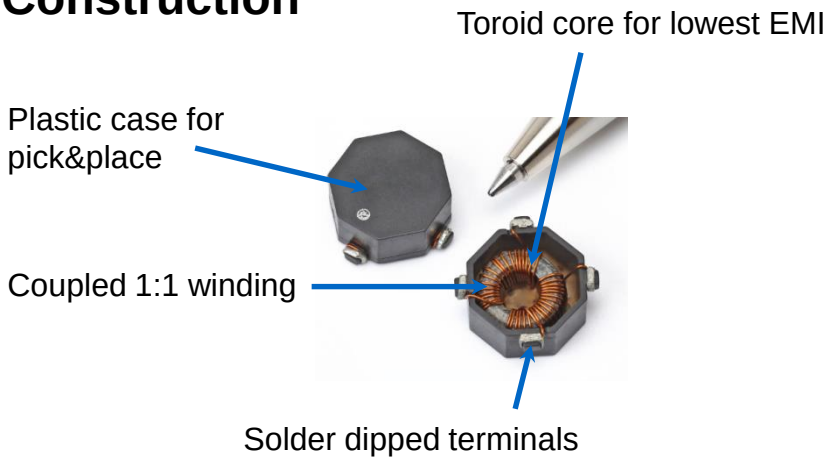
Automotive SMT Toroid Coupled

Construction



Features/Benefits

- Toroid core with lowest EMI capability
- 3 different core materials: ferrite, powdered, amorphous
- 4 different sizes
- Wide inductance range
- 1:1 transformer or coupled inductor
- 300VDC isolation

Typical Applications

- Infotainment
- Telematics
- Any SEPIC drive

Examples:

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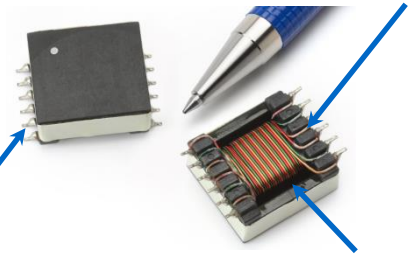
Automotive DC-DC Transformers

Construction

Core and header selected or developed to provide the optimal solution



SMT or THT

Clip or wire winding

Features/Benefits

- Optimized performance using stanard or unique core shapes and sizes
- High power density
- High efficiency using advanced core materials

Typical Applications

- Bidirectional DC-DC converters
- Current sense applications for ECU, break controllers
- Isolated motor drive controllers

Examples:

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Supercapacitors

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HV Series Supercapacitors

Automotive OEM Qualified:

- 25F used for qualification testing to OEM requirements
- Qualification test elements:
  - Leakage Current
  - Self Discharge
  - Cycle life – 6000 charge/discharge cycles (-40, +25, +80C)
  - 80C Aging Test – 4700hrs
  - Mechanical Shock test: 30g/6ms, half sine, 100k shocks

Features/Benefits

- Broad capacitance ratings
- Lowest ESR (Aerogel Technology)
- Broad temperature range: -40 - +85C
- Long lifetime (15yrs)
- Robust mechanical construction

Typical Applications

- Electrification of vehicles require localized power for
  - Safety
  - Cabling cost reduction
  - Pulse/peak power reduction
- Door locks (design in)
- Trunk locks (in design)
- E-call unit backup power (in design)
- Dynamic suspension (in design)

Cross Reference

Cap	Eaton HV Series	Maxwell	Nichicon
1	X	X	-
3	X	X	-
5	X	X	-
6	X	-	X
10	X	X	X
15	X	-	X
25	X	X	X
35	X	-	-
60	X	X (50)	-
100	X	X	-

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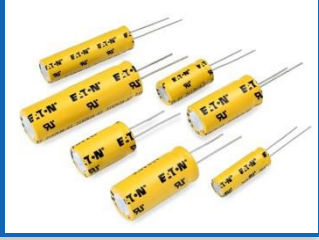
TV Series Supercapacitors



Product Description

- 3V per cell technology
- Longest lifetime product available
- Recommended for automotive
- Highest power and energy density supercap cell on the market

Features/Benefits

- Broad capacitance ratings
- Lowest ESR, especially <50F
- Broad temperature range: -40 - +65ºC, 2.6V/85ºC
- Factory TS16949 certified

Typical Applications

- Electrification of vehicles require localized power for
  - Safety
  - Cabling cost reduction
  - Pulse/peak power reduction
- Door locks (design in)
- Trunk locks (in design)
- E-call unit backup power (in design)
- Dynamic suspension (in design)

Key Specifications

TV Part Numbers	Capacitance (-10% / +30%)	DC ESR (Max)
TV1020-3R0605-R	6F	35 mohm
TV1030-3R0106-R	10F	27 mohm
TV1325-3R0156-R	15F	24 mohm
TV1625-3R0256-R	25F	17 mohm
TV1245-2R0346-R	34F	16 mohm
TV1635-3R0356-R	35F	14 mohm
TV1840-3R0606-R	60F	13 mohm
TV1860-3R0107-R	100F	11 mohm

X Series Supercapacitors Cells

XV/XB/XT Series Features/Benefits

- Highest energy density in 300F, 400F, 600F
- Very Low ESR and slow ESR degradation due to special electrode structure
- Broad temperature range: -40 - +85C
- Long lifetime (15yrs)
- Robust mechanical construction
- Available 2.5V, 2.7V or 3.0V cells

Applications

- Energy regeneration and return up to 10'skW mild hybrids, micro hybrids
- Peak power battery support (start-stop system, EPS)
- Vehicle tracking and anti-theft systems mains power

XL Series Features/Benefits

- Highest power density on the market (0.23mOhm DC ESR)
- High capacitance
- Ideal for high energy transfer applications
- Broad temperature range: -40 - +85C
- Available with weldable or scew-mount terminals

Applications

- Energy regeneration up to 100'skW for full hybrids
- Electric engine boost
- Peak power battery support in trucks, buses, commercial vehicles

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Standard Supercapacitor Modules

- PN: XVM-16R2656-R
- 65F / 16V per module
- 22mOhm ESR – 20Amp continous
- Passive voltage balancing
- Series and parallel connections allow offers a well scaleable solution for specific power and voltage levels
- Typical application: energy buffer during braking and acceleration 1-10kW – parallel connected to the battery

- PN: XLM-48R6167-R
- 166F / 48V – max voltage 750V with multiple modules connected in series
- 5mOhm ESR – 86Amp continous
- Active voltage balancing
- Ruggedized construction for harsh enviromnents (IP65)
- Typical application: energy buffer for 100kW+ during brake energy regeneration and boost during acceleration

Circuit Protection

Powering Business Worldwide

AEC-Q200 Qualified SMT Fuses

Part Series	Part Image	Part Description	Current Range (A)	AEC-Q Grade	Date Of Qualification
3216FF		Fast Acting Chip Fuse	0.25 - 30	1	2010
CC12H		High Inrush Current Chip Fuse	1 - 20	1 - <20A 3 – 20A	2014

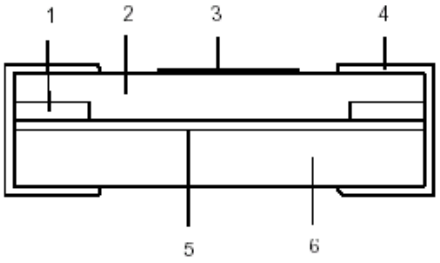
Applications:

- Battery management system sense line protection
- Spark igniter
- Infotainment system

3216FF Fast Acting Fuse

The Eaton Bussmann ® 3216FF Chip™ fuse Series provides fast acting performance coupled with the thermal advantages of a ceramic solid matrix construction.

- Current Rating: 0.25A-30A
- Fast-acting performance
- Voltage Rating: 64V/32V/24V depending on current rating
- Lead/Halogen free and RoHS compliant
- Standard termination design for easy solderability (1206 size)
- Applications: ECU, Airbag control unit, Infotainment, battery management system
- ADVANTAGE 3216FF: WIDE TEMPERATURE RANGE and WIDE SELECTION OF RATINGS



1. Silver termination pad
2. Cover glass
3. Ampere mark
4. Nickel barrier
5. Metal film fusible element
6. Ceramic substrate

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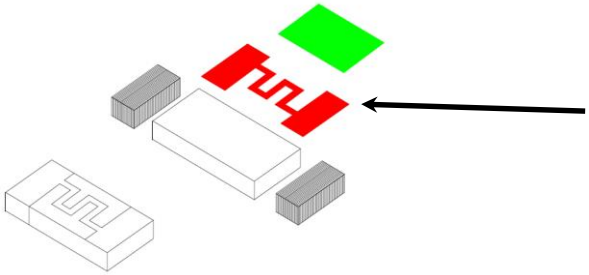
CC12H High Inrush Current Fuse

The Eaton Bussmann ® CC12H Chip™ Chip Fuse Series provides good inrush withstand performance coupled with the cycling advantages of a ceramic solid matrix construction. It's a cost-effective solution for applications in which high inrush currents and/or on-off cycling are present. Current Rating: 1A-20A

- Fast-acting performance
- Voltage Rating: 63V/32V depending on current rating
- Lead/Halogen free and RoHS compliant
- Standard termination design for easy solderability (1206 size)
- Applications: ECU, Spark igniter, Infotainment, LED lighting
- ADVANTAGE CC12H: HIGHER CURRENT RATINGS AVAILABLE THAN COMPETITION (8A vs.20A)



Solid matrix design for better heat distribution

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Eaton Bussmann Series EV Fuse Family

- Automotive Grade
  - JASO D622 Compliant
  - TS16949 Manufacturing
- Various mounting terminations (blade, bolt down, ferrule)
- Highest power density
  - 500 VDC (Best in Class)
  - 5-400A (Best in Class)
  - 20kA Interrupting Capability (Best in Class)
- Industry's fastest performance for protection of components and auxiliary loads
- Increased cycling capability for sustained life in EV applications
- Applications: electric drivetrain, in-car chargers

	Body Size (mm)			
Rating (A)	10.3	20	25	30
5	x			
7.5	x			
10	x			
15	x			
20	x			
30	x			
40	x			
50	x	x		
60		x		
70		x		
80		x		
100		x	x	
125		x	x	
150		x	x	
175			x	
200			x	x
225			x	x
250			x	x
300				x
350				x
400				x

Powering Business Worldwide

AEC-Q200 Qualified ESD Protection Elements

Part Series	Part Image	Part Description	Current Range (A)	AEC-Q Grade	Date Of Qualification
PS04LTVA		Ultra Low Capacitance ESD Supressor 12VDC	C_{typ}=0.05pF	1	2010
0402ESDA-AEC1		Ultra Low Capacitance ESD Supressor 30VDC	C_{typ}=0.05pF	1	2017

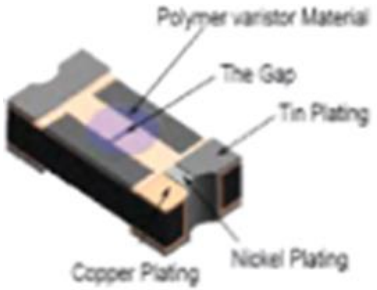
Applications:

- Radio antenna protection
- 3G/4G/5G GSM antenna protection
- Ethernet communication line protection
- USB hub protection

Ultra Low Capacitance ESD Supressor Technology

The Eaton Bussmann ® PS04LTVA PolySurg™ ESD supressor provides the ultimate protection against ESD strikes for all signal or data lines.

- Ultra low capacitance 0.05pF allows to use it for all antenna and fastest dataline protection (USB 3.0)
- Designed to supress IEC61000-4-2, Level 4 ESD waveforms
- Up to 12V or 30V continous voltage capable
- Low trigger (150V) and clamping voltage (25V)
- Can withstand over 1000 ESD strikes
- Lead/Halogen free and RoHS compliant
- Standard 0402 size
- Applications: Infotainment USB/SD port and keypad protection, Antenna input protection
- ADVANTAGE OVER COMPETITION: LOWEST CAPACITANCE AND CLAMPING VOLTAGE



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Automotive Applications Served

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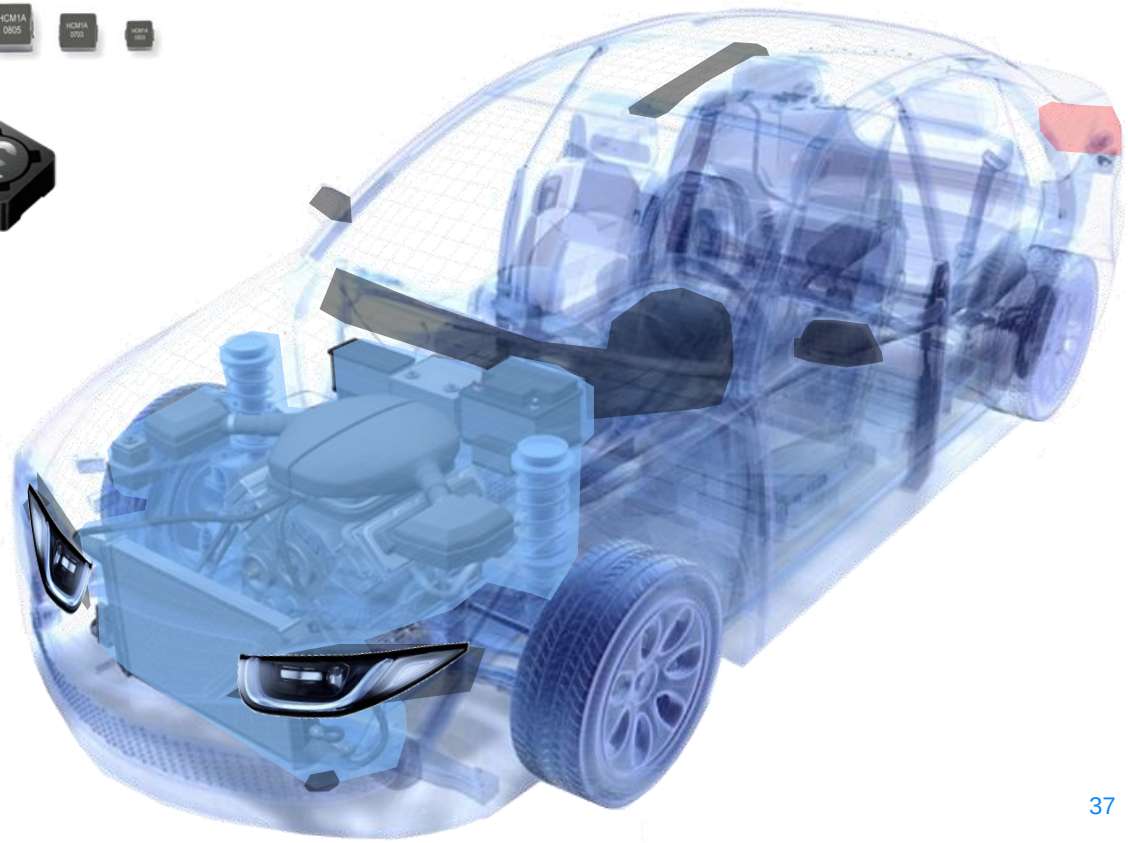
Automotive - LED Lighting

Applications:

- Headlights
- Daytime Running Lights
- Tail Lights
- Fog lights
- Safety/bay Lights
- Instrument cluster (LCD)
- Reading lights
- Ambient lights



OEM References in EU & Korea:

- Hyundai
- KIA
- Ssangyong
- Audi
- BMW
- Jaguar
- Land Rover
- MAN
- Opel/GM
- KTM
- Etc.

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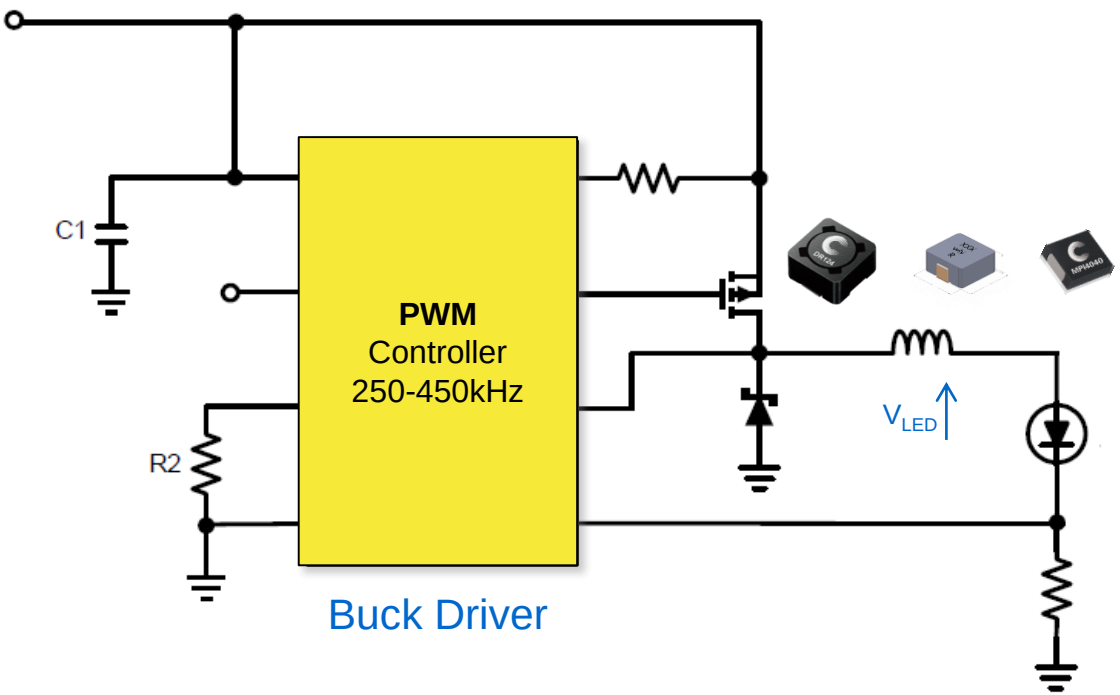
Low Power Indicator or Back Lighting - Buck

DRA73/74 / MPIA4040 / HCMA0503 / HCMA0703



Buck Driver

Typcial Inductors supplied:

- DRA73/74 or MPIA4040 for lower power
- HCMA0503 or HCMA0703 for higher power
- 4.7-22uH
- 1-2A
- AECQ-200 Grade3

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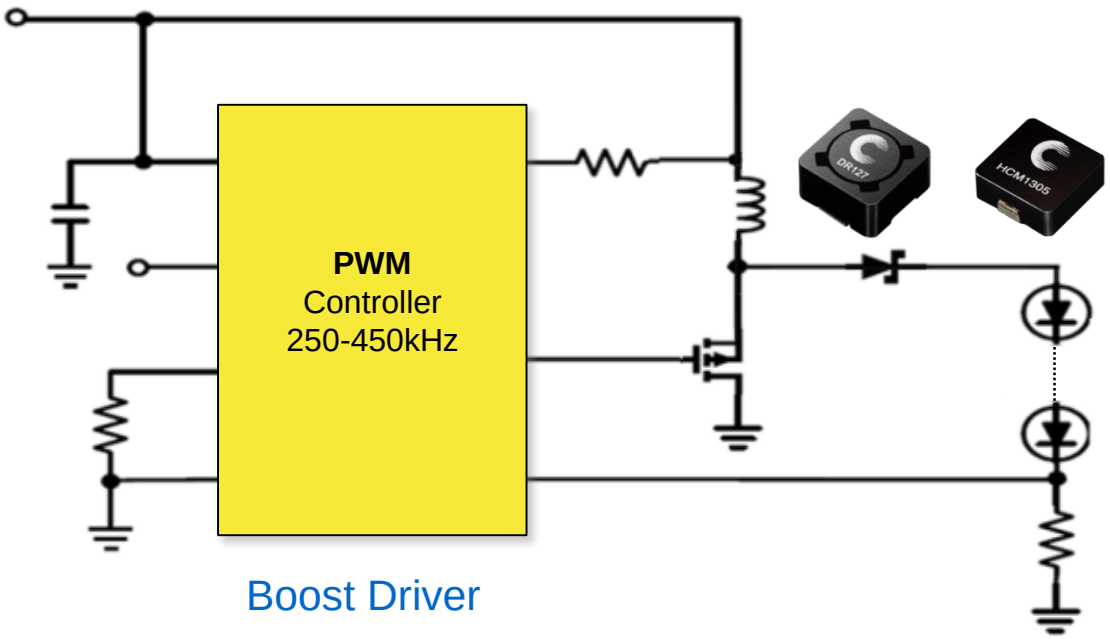
High Power Headlight - Boost

DRA125/127 / HCM1A1305



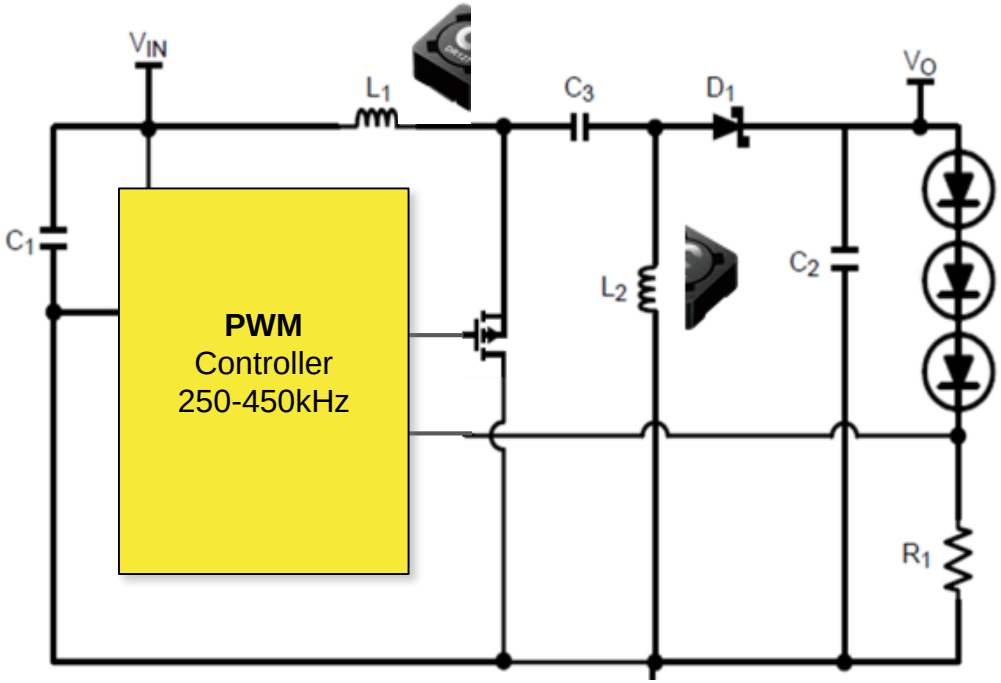
Boost Driver

Typical Inductors supplied:

- DRA125/127 for lower power 2-3A
- HCM1A1305 for higher power
- DRA74 or HCM1A0703 for input filter
- 4.7-100uH
- 2-5A
- AECQ-200 Grade1

Daytime Running Light - SEPIC

DRA127 / DRAQ127 series



SEPIC Driver

Typical Inductors supplied:

- DRAQ127 series 1:1 coupled inductors
- 2pcs DRA127 for higher power
- DRA74 for input filter
- 4.7uH-47uH
- 2-3A
- AECQ-200 Grade1

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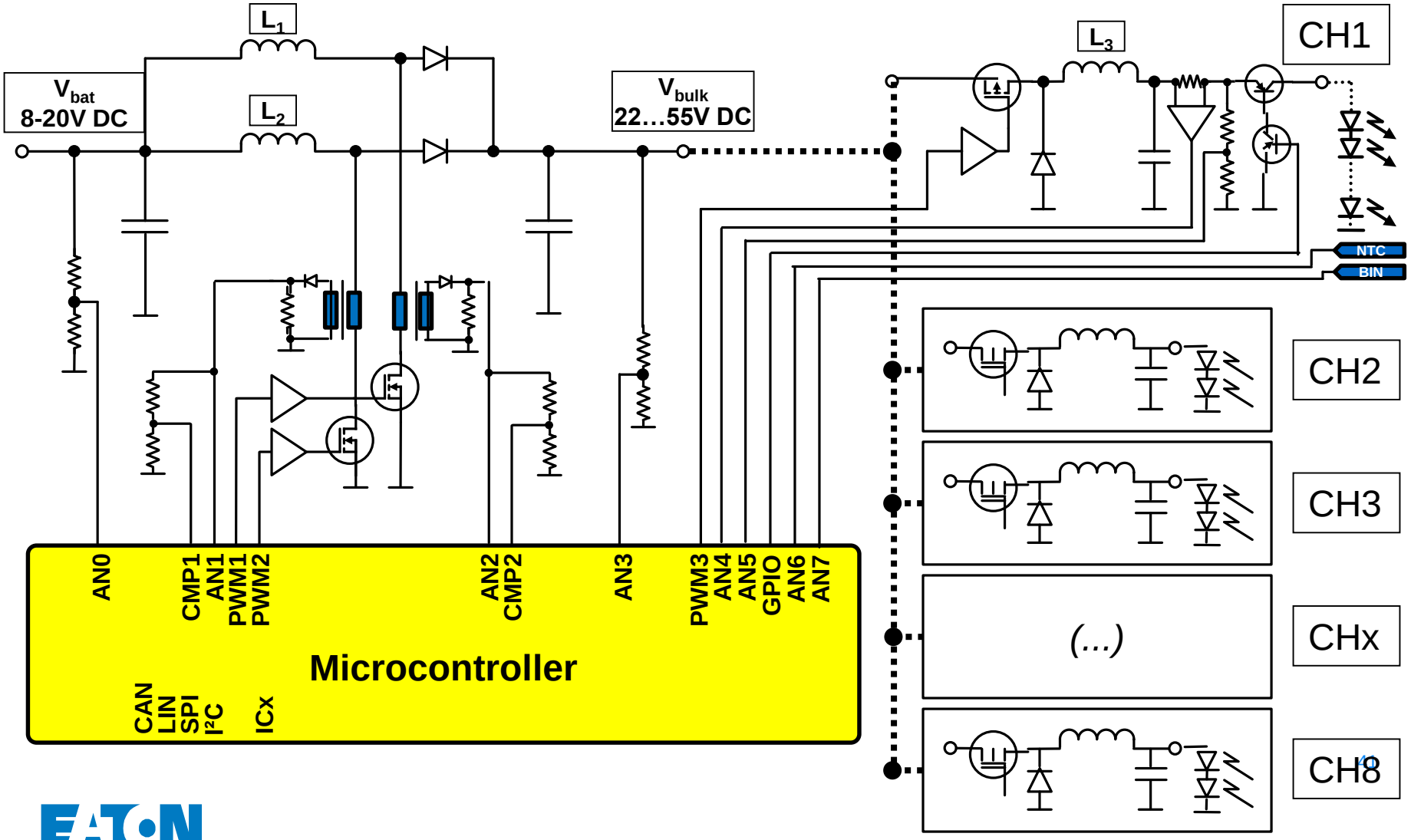
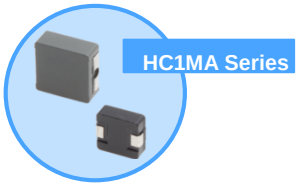
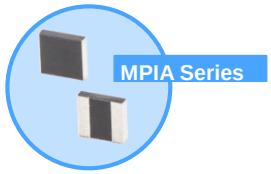
Intelligent LED Headlight – Boost & Buck



Powering Business Worldwide

Intelligent LED Headlight – Boost & Buck





Typical Inductors Offered:

- DRA127 or HCM1A1305/1307 for input filtering
- HCM1A1707 or 2pcs HCM1A1305/1307 for boost stage
- DRA127 for buck stages
- HCM1A0503 or MPIA4040 for output filters
- HCM1A series was specifically developed for high board temperature (120-130C) filter inductor
- DRA series offers highest efficiency

Complex DRL&Low Beam LED Driver Example

- 1x DRAQ127 / PCBA
- 1x DRAQ75 /PCBA
- 1x HCMA0703/PCBA
- 1x HCM0503/PCBA
- 2x PCBA per car

Complex Full LED Driver Example

- 3x HCM1A1307 / PCBA
- 12x HCM1A0805 /PCBA
- 2x PCBA per car

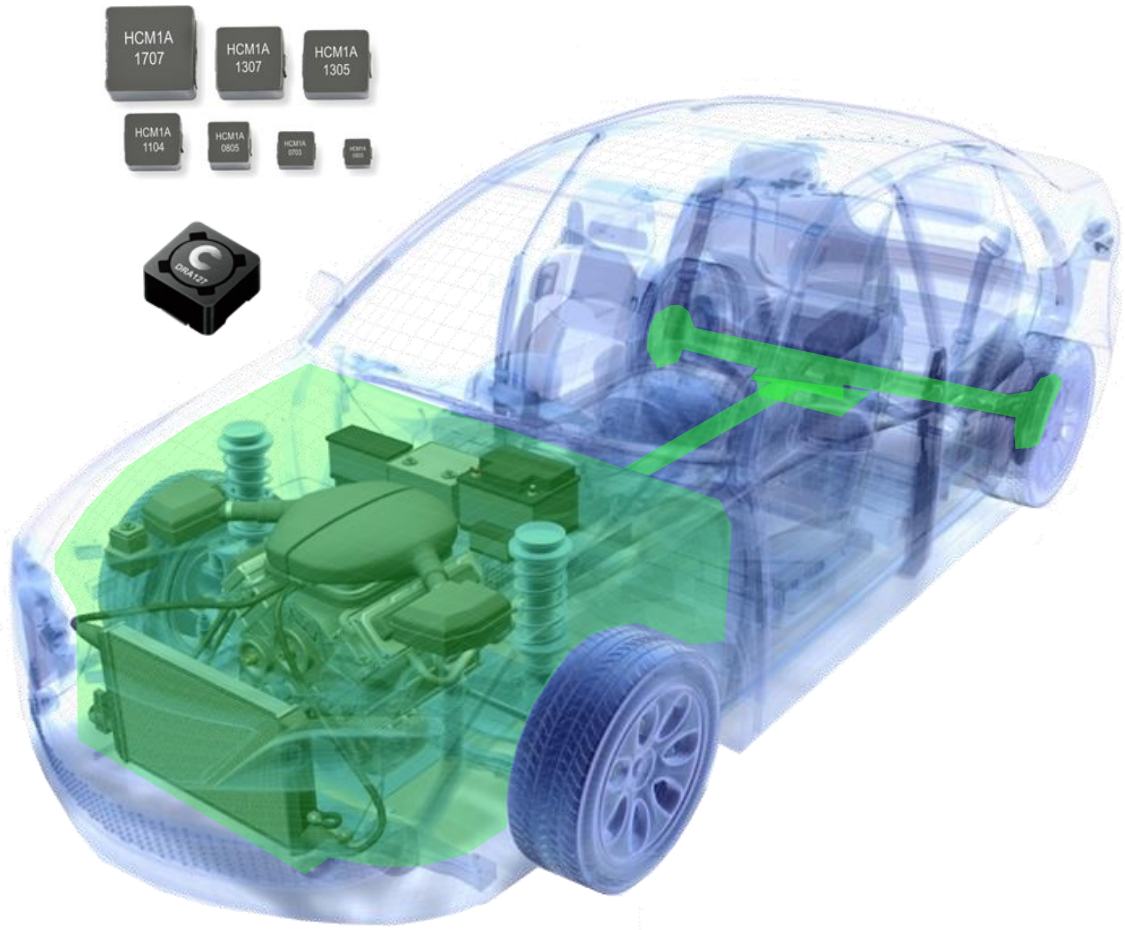
Automotive – PowerTrain & Engine Management

Applications:

- Engine ControlModules (ECU)
- Transmission Controls (TCU)
- Fuel pump
- Engine cooling pump
- Engine cooling fan
- Oil pump
- e-Turbo
- e-Brake
- Active suspension controller

OEM References in EU & Korea:

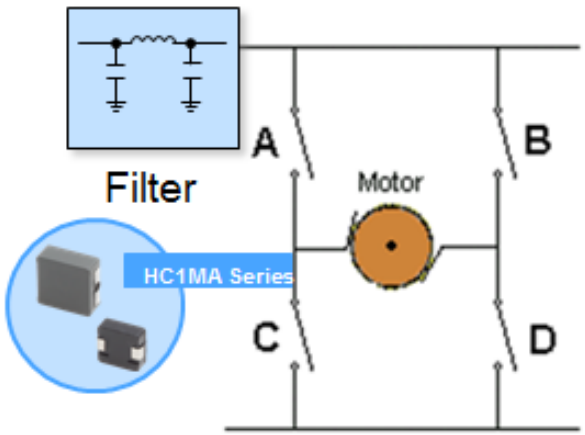
- Hyundai
- Kia
- Renault-Samsung
- VW
- Daimler
- Volvo
- Opel
- Jaguar/Land Rover



Powering Business Worldwide

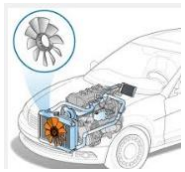
Electrified Pumps & Actuators In PowerTrain

Under-the-Hood



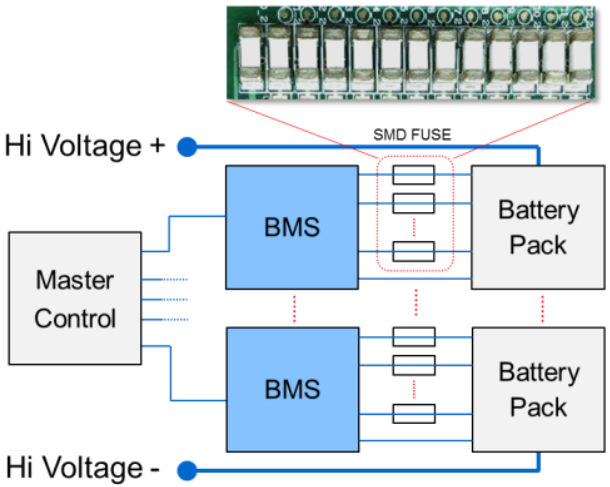
Market Adoption of Electronic Controls in The Engine Bay

- Electonic controlled pumps and actuators can work with ECUs with better efficiency and better management of the engine thermal
- Mechanical belt driven pumps are bulky and heavy
- Turbocharger boost is only available by heavy exhaust and needs to be oversized to get the right performance. E-Turbo can provide boost until the engine revs up and change to be exhaust gas driven when it's optimal
- eBrakes can significantly reduce the weight of the brake system eliminating the hydraulic system components
- Electric motor controllers emit a lot of noise => input filter is necessary
- Car's electric power requirement is getting increased significantly up to 20kW to be able to supply all the new electric subsystems



Powering Business Worldwide

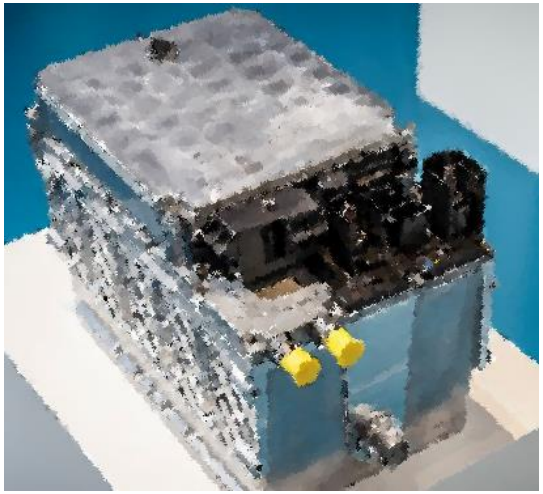
HEV Li Battery Management System



- Li cells are very sensitive for over and undervoltage and overtemperature
- Battery management system is continously monitoring all Li cells (1.2V typically) individually and control the voltage level
- BMS contains a wide array of cabling which are suspected to be short circuited => all line needs to be protected by a fuse
- Typcially 2 fuse/cell required => 60 fuses required for a 48V Li battery

Fuse challenge:

- Small 3216 max
- 63-80VDC rated
- Breaking current capacity vs. DCR needs to be aligned with system total impedance
- Low I2t is better than high I2t – needs fast action
- 3216FF is ideal fuse to do the job



Powering Business Worldwide

12V – 48V DCDC Converter For Mild Hybrids

- 48V/12V dual battery systems including mircohybrid energy regeneration requires a 3-10kW size DCDC converter and optionally supercaps for regenerated energy storage and peak shaving
- Design consists of 8-12pcs large power inductors + 20pcs 400F supercaps in series + additional PI or Common Mode Choke

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Mild Hybrid Example: Mazda 6 i-Eloop

Supercap solution:
10 x 3000F cells

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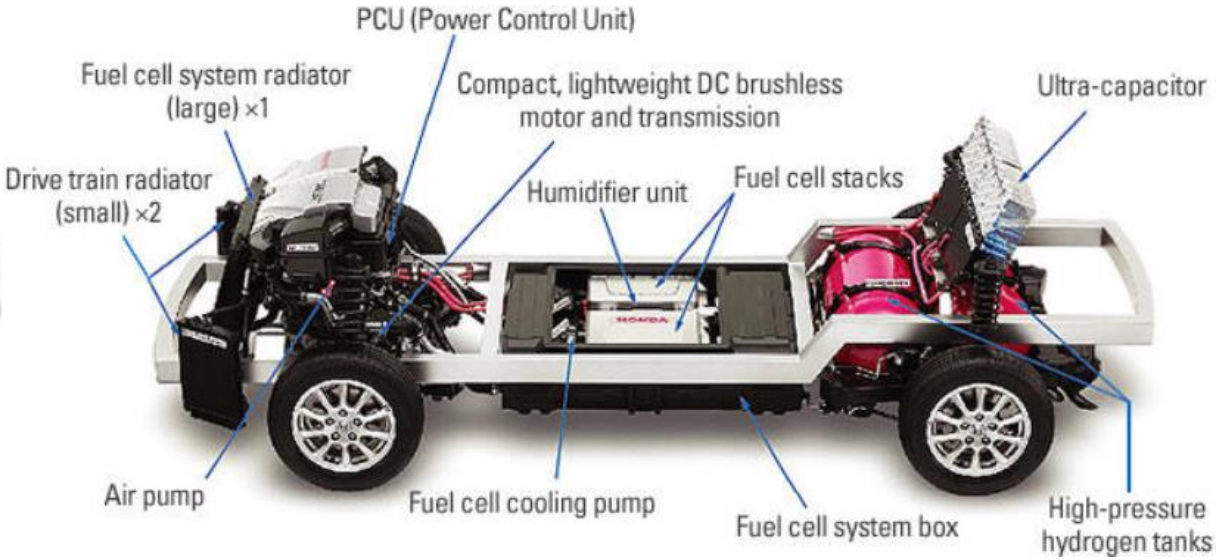
Electric Delivery Truck Power Boost

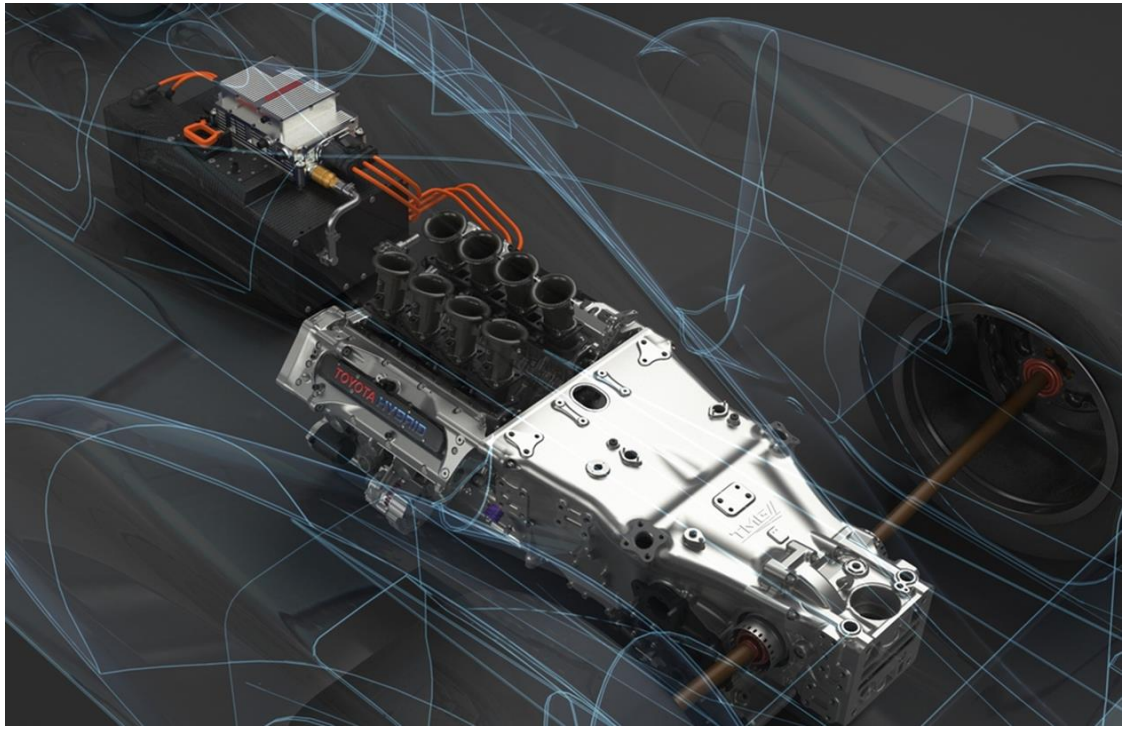
- Primary battery can be LiIon or Sodium Nickel Chloride (hot battery ~240C) with very high energy density and long lifetime, but poor power density. Supercap bank is to provide energy for acceleration (~60kW) and regenerate breaking energy
- Solution tested for 1year by DHL with very good result
- 4pcs XVM-194R4835-R

Power Boost Example: Honda FCX



- Fuel cell vehicle +70 x 3000F supercap cells
- Supercap is regenerating breaking energy and resupplies to the electric engine
- Using supercap improves efficiency and acceleration performance

Power Boost Example: Toyota Yaris R



- Supercap regenerates braking energy
- No battery used
- Supercap releases 120HP boost for max 5s during acceleration

Capabus – Pure Supercapacitor Energy Storage

- Since city buses stops frequently, break energy regeneration is a good way to save energy, but still fully electrical buses are very expensive initial investment, mainly due to the battery cost.
- The buses stops in about every 2kms for at least 10 seconds while passengers are getting on and off the bus.

Why not to use supercaps to power the buses between stations and recharge the caps during the time passengers are getting on and off the bus?

Capabus – Pure Supercapacitor Energy Storage

Implementations:

- Shanghai – 100 capabuses in operation
- Moscow – park buses (20km/hr, 30min operation with one charge)
- Paris – MAN capabuses are under testing
- Vienna – Overhead fast charging – using special batteries at the moment...supercap is an option

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Supercapacitor Engine Starter

Solution

- Passanger car <2.0L, 250A : 1x Supercapacitor Modules (400F 5pcs in series)
- Truck >10L, 1200A: 1x Supercapacitor Module (3000F 2px6spcs)

Feature

- Quick charge, no pre-charge needed.
- Safe, High reliability and Green
- Excellent performance in extreme temperature (-40° C to +65° C)
- Maintenance free. Eliminate shelf life issue of battery solution.
- Light weight, Small size

XV3560-2R7407-R

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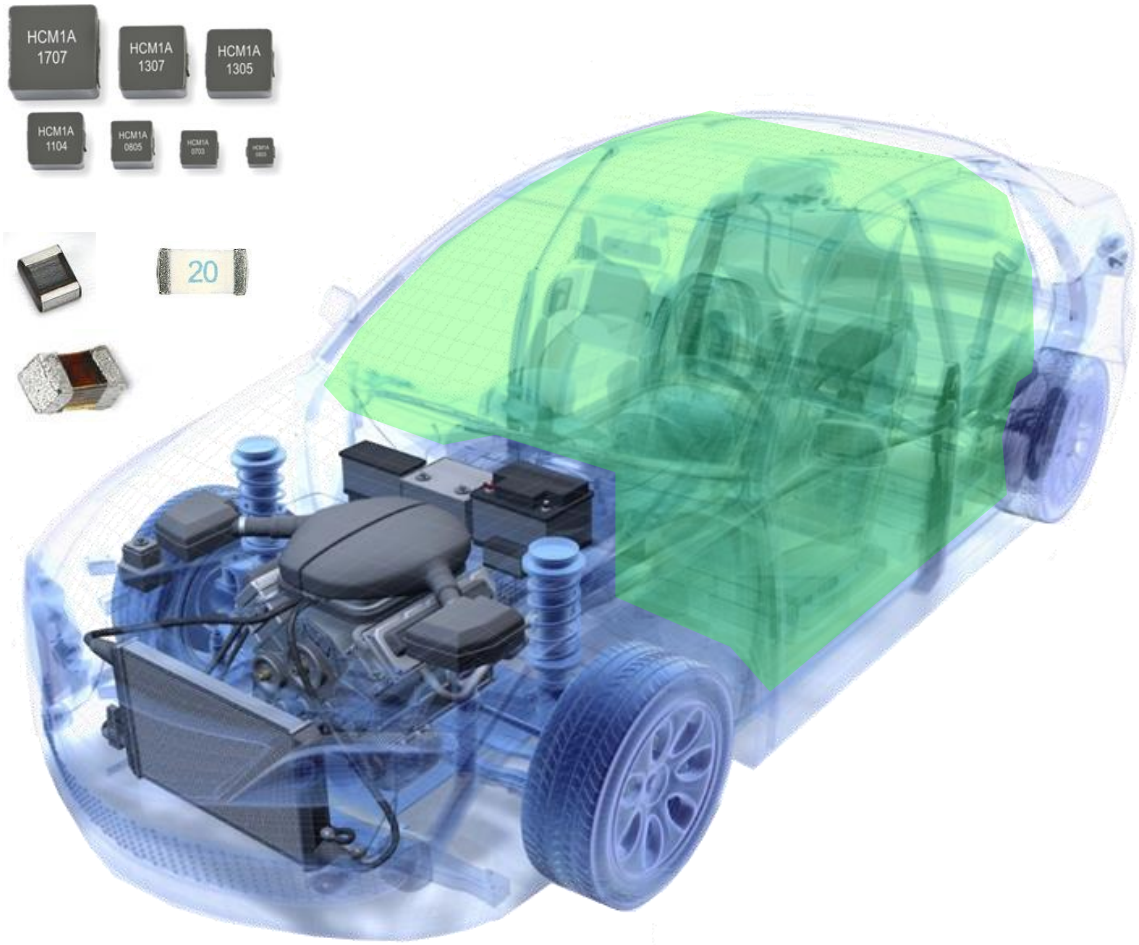
Automotive - Passenger Compartment

Applications:

- Infotainment
- Telematics
- Instrument Clusters
- Climate Controls
- USB&Wireless Chargers

Reference OEM in EMEA:

- BMW
- VW
- Audi
- Skoda
- Daimler
- Volvo
- Ford



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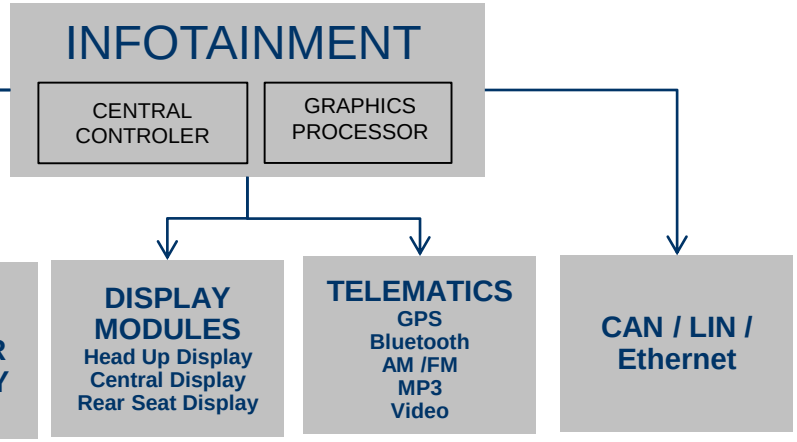
Infotainment Power Management



Automotive Grade Inductors

	AUDIO Class D Amplifier	MAIN POWER SUPPLY	DISPLAY MODULES	TELEMATICS	CAN / LIN / Ethernet
HCM1A	4pcs	8pcs	4pcs	2pcs	1pc
DRA / DRAQ					
HC3A					
MPIA					

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Automotive Phone Charger - USB

Application

- Application: Phone or Tablet charger and interface which is automotive grade (shock, vibration, temperatures)
- Convert battery voltage to 5V USB output
- 1 or 2 channel outputs, each channel 5V2.1A. Max. 25W for 2 channels
- Good overall EMI immunity – load is level and device connected can influence EMI

Application Image

Component Requirement

- Automotive grade component is a plus, but not always required
- Size restriction and limited space
- Shielded construction – low EMI
- Good heat dissipation – limited cooling of the board
- Ambient temperature: -40/+85C

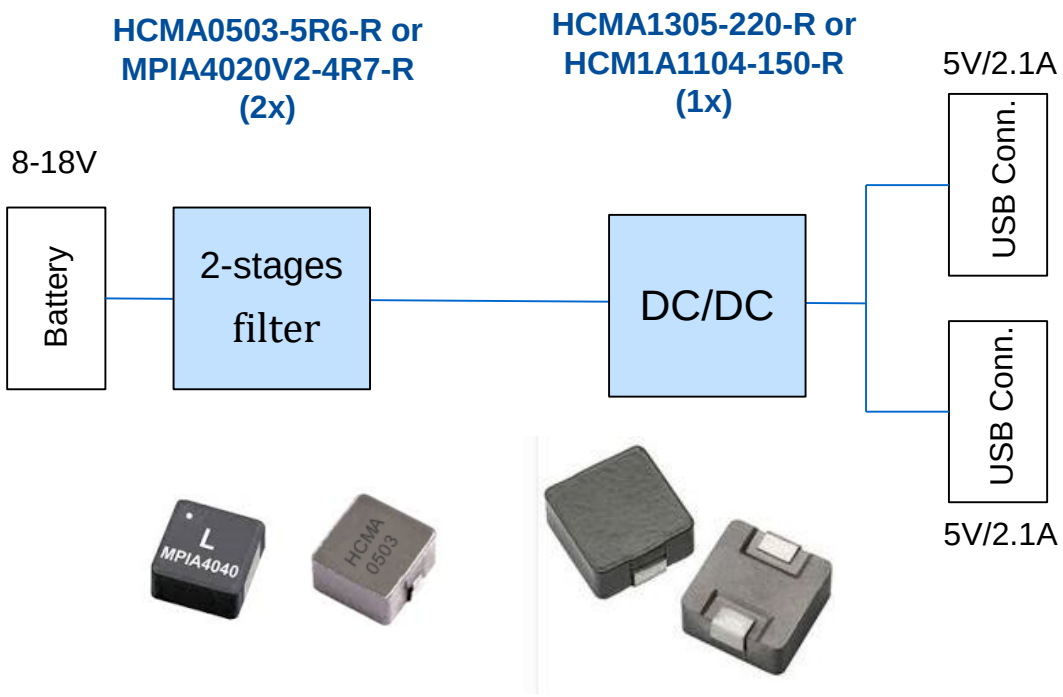
Eaton Solution

- High power density inductors: MPIA4040/HCMA0503 for filtering & HCMA1104/1305 for buck converters
- AEC-Q200 qualified
- Fully shielded – low EMI
- High Irms and Isat in small package
- Excellent temperature stability
- Small size

Powering Business Worldwide

Automotive Phone Charger - USB

Block Diagram



Powering Business Worldwide

Automotive Phone Charger - Wireless

Application

- Application: wireless phone charger which is automotive grade (shock, vibration, temperatures)
- Convert battery voltage to magnetic field which is suitable to charge phones with associated recevier
- Power level is 25-30W – effective charging is ~20W
- Very good overall EMI immunity required – load is level and deviating and oscillators are generating both conducted and radiated emission

Application Image

Component Requirement

- Automotive grade component is a plus, but not always required
- Size restriction and limited space
- Shielded construction is critical – very low EMI
- Good heat dissipation – limited cooling of the board
- Ambient temperature: -40/+85C

Eaton Solution

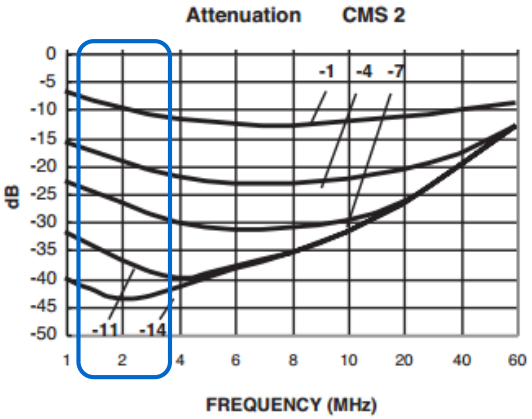
- High power density inductors & common mode:
  CMS for common and differential mode filtering
  HCMA0503/DRA7x for buck converters
  CC12H for overvoltage & short circuit protection
- AEC-Q200 qualified
- Fully shielded – low EMI
- High Irms and Isat in small package
- Excellent temperature stability

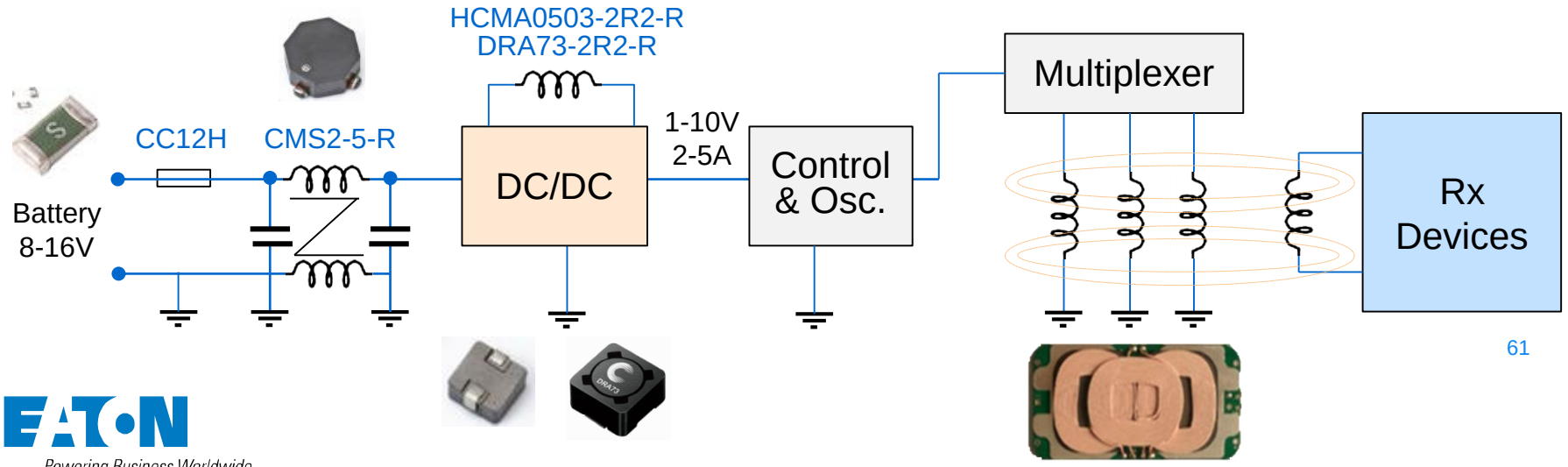
Powering Business Worldwide

Automotive Phone Charger – Wireless

Block Diagram

- DCDC converter switching frequency is high normally ~2MHz => 2.2uH inductor is required and input filter which can supress noise in this range efficiently
- CMS2's best efficiency is 1-5MHz





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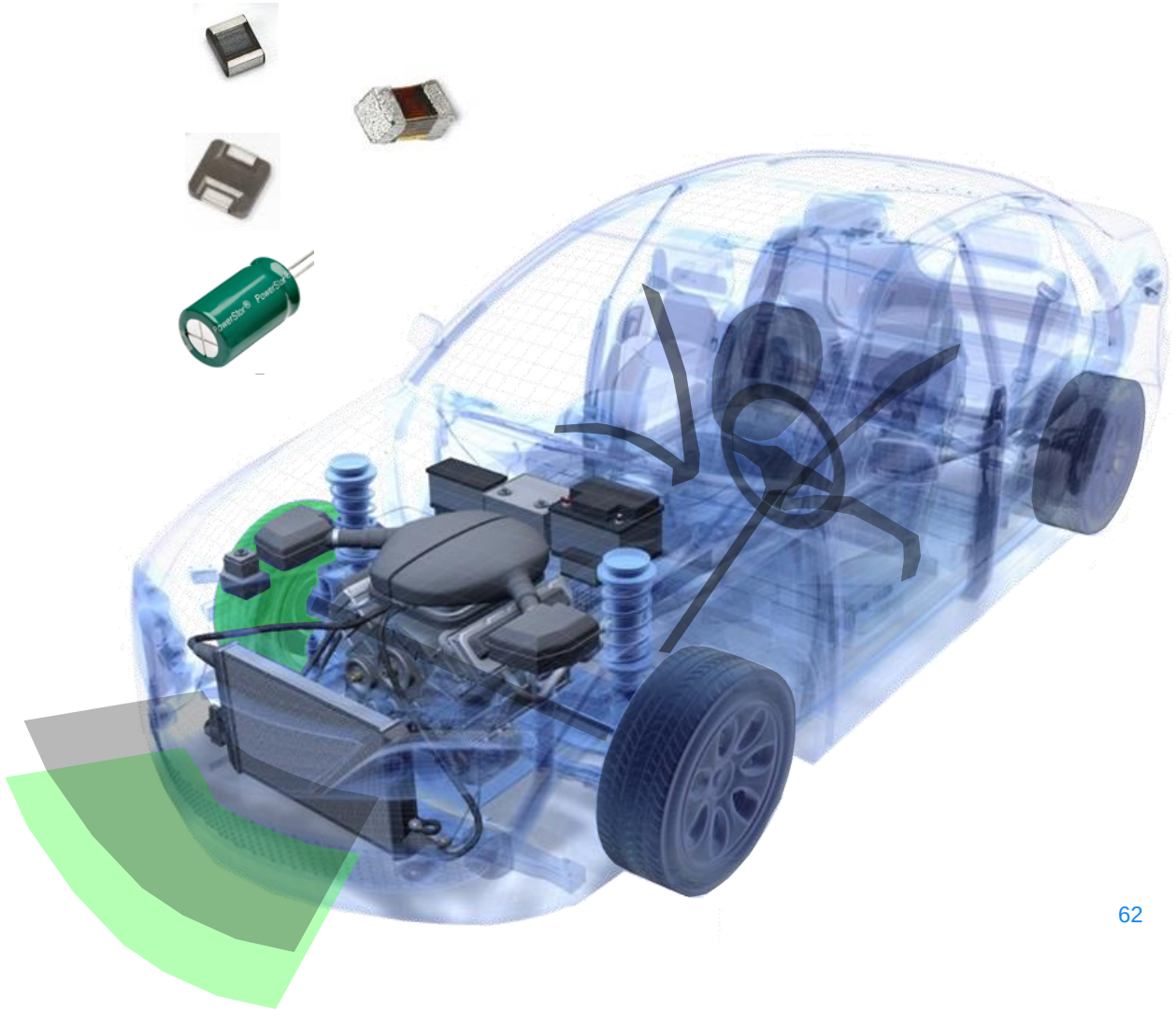
Automotive - Safety & ADAS

Applications:

- Adaptive Cruise Control
- Vision Systems
- Seatbelt Systems
- Emergency call unit
- Connected Car
- Power Safe Door Locks
- Airbag Clusters
- Traction Stability Systems

OEM References in EU & Korea:

- Hyundai
- KIA
- Audi
- BMW
- PSA



Powering Business Worldwide

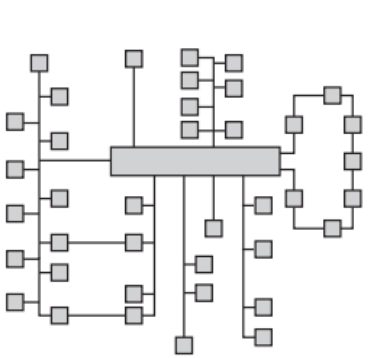
Advanced Driver Assistance System

- Each sensor and camera needs to be powered & protected separately
- MPIA40-V2 inductor family is ideal for camera power 2x per camera normally used
- CC12H fuse is ideal for individual protection due to long harnesses and being directly powered by central junction box which is 10-20A fused while camera power requirement is 1A only

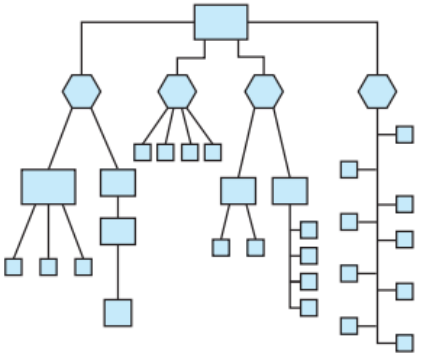
Automotive Ethernet

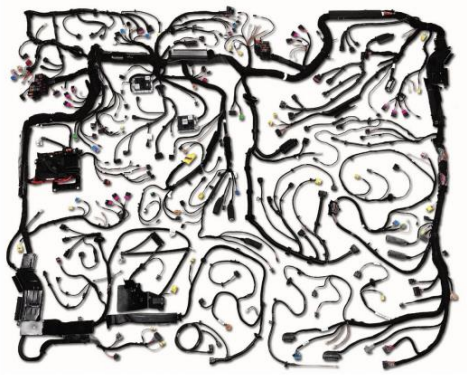
- Car domains (body electronics, engine controls, ADAS, telematics, etc.) are more and more tend to communicate with each other
- High data speed and less cable is needed => 100Base-T1 Ethernet with 2 wire twisted can resolve the issue while CAN, MOST, LAN etc. Can't
- Need high speed port protection
- Opportunity for up to 100x 0402ESDA-AEC1 ESD supressors per car
- SOP 2020 for most carmakers

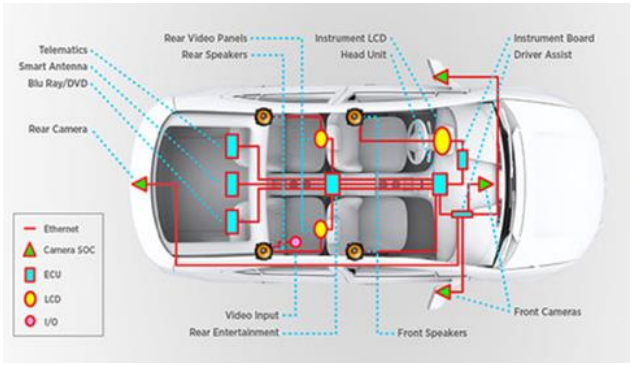
Current Communication Structure



Future Communication Structure







Powering Business Worldwide

Connected Car – 4G/LTE Modems

- Audi was first to implement this feature to get to a real connected car
- PS04LTVA1 ESD supressor could only work for the high speed antenna protection. 3x per car is used
- 28V line capability is needed => 0402ESDA-AEC1 developed for it

Powering Business Worldwide

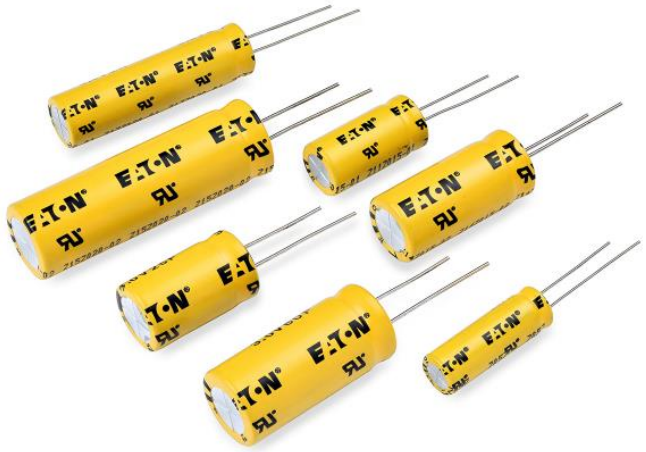
Automotive e-Call Unit

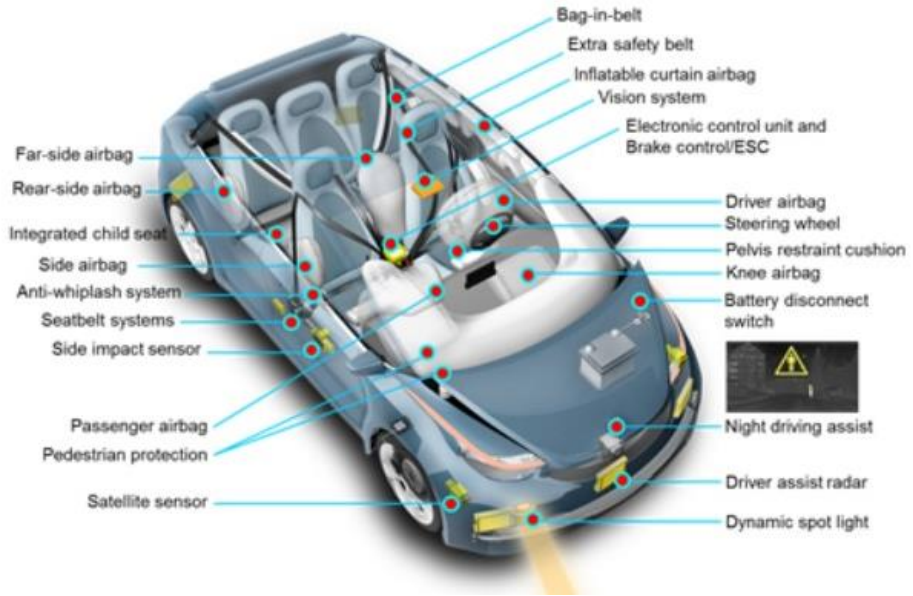
- eCall is getting requirement in specific markets => OEMs needs to adopt HW and SW to be able to sell in countries
- Largest OEMs are GM, PSA , BMW, Daimler, Volvo already adopted this feature
- HCMA0703 is used for DCDC using high frequency to downsize the PCB as much as possible – need high EMI shielding
- MPIA40-V2 is used for output filter to the speakers
- HV/PHV supercaps are for storing the required energy for operation

Powering Business Worldwide

Active Safety Backup HUB & Distributed Power Backup

- Hybrid and Electric vehicles are to be disconnect their battery in accident
- Regular vehicles have the chance of battery disconnection during accidents
- Without power the passive safety equipments (airbags, seat belts, body controls, emergency lighting, etc.) will not work
- New car designs are adding a backup battery or supercap pack to store enough energy in case of battery disconnection in accidents
- Normally 4x100F TV capacitors can store the required energy



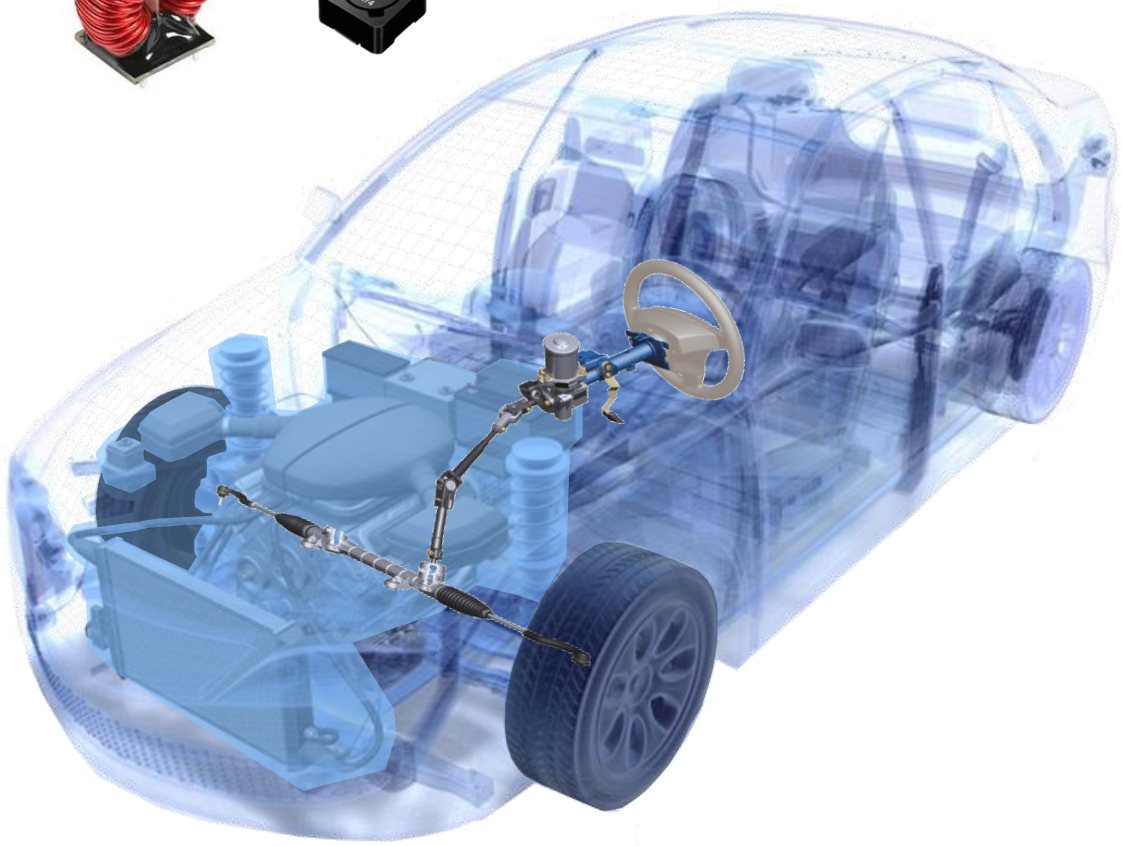


Powering Business Worldwide

Automotive - Electronic Power Steering

References in EU with complete magnetics solution:

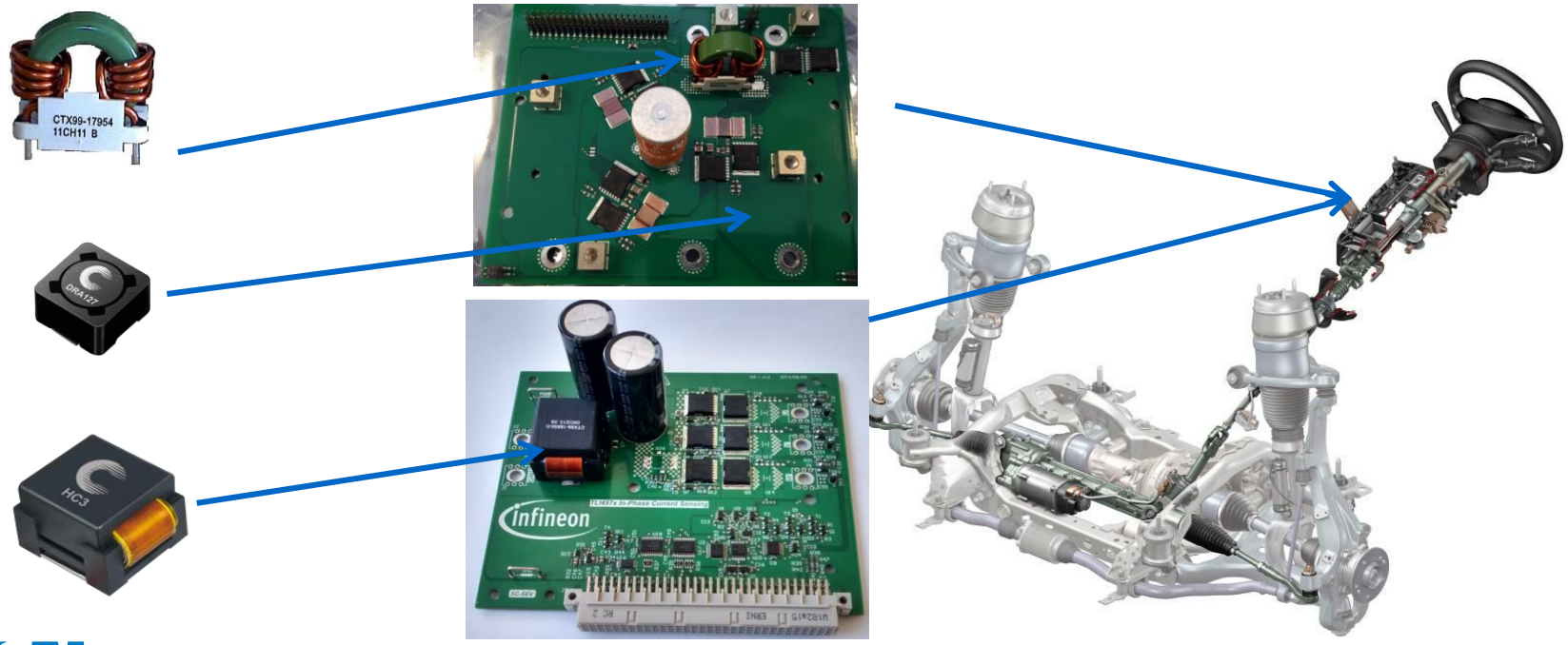
- PSA
- Opel
- Ford



Powering Business Worldwide

Electronic Power Steering Example

- Standard inductors and custom design inductors & filters for high power EPS controllers
- Challenges: high power parts, high reliability for critial applications



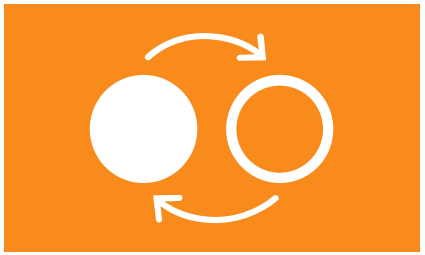
Powering Business Worldwide

Engineering Resources

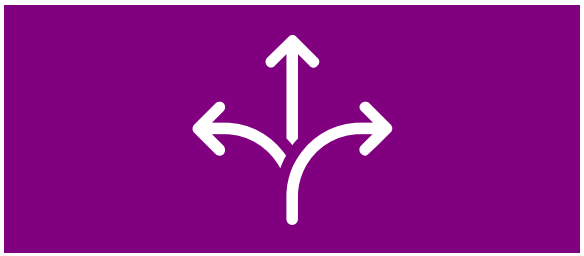
Data Sheets

Tools

Parametric Search

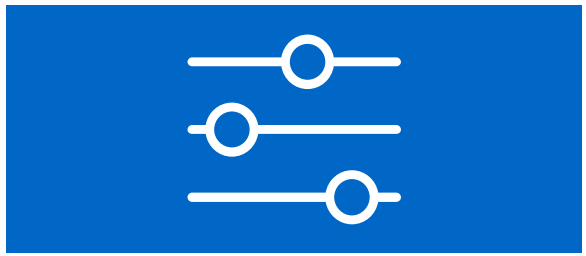


IC Matching



Cross Reference

Supercapacitor Calculator



Connector Configurator

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Thank You!