

EV Battery Charger A Critical Link



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Presentation points

- Delta-Q perspective
- Voice of Customer (Market Requirements) for battery chargers
 - Automotive OEM needs
- QMX Family
- Technology Advances
- Conclusion

Delta-Q Perspective

- Tier One supplier to industrial EV manufacturers
 - 500,000 chargers fielded since 2003, currently shipping at >10k/month
 - *Primary application... 50 – 150 vehicle fleets*
- In-House Product Design and Development
- Sales, Marketing and Customer Service
- ***Auto OEM chargers manufactured and marketed through global Tier 1 supplier***

Voice of Customer

- Low cost
- Size, weight
- Long design life
- High efficiency
- Flexible, yet optimized power level
- Universal input, regulatory & standards compliance
- Proven supplier (Tier One)

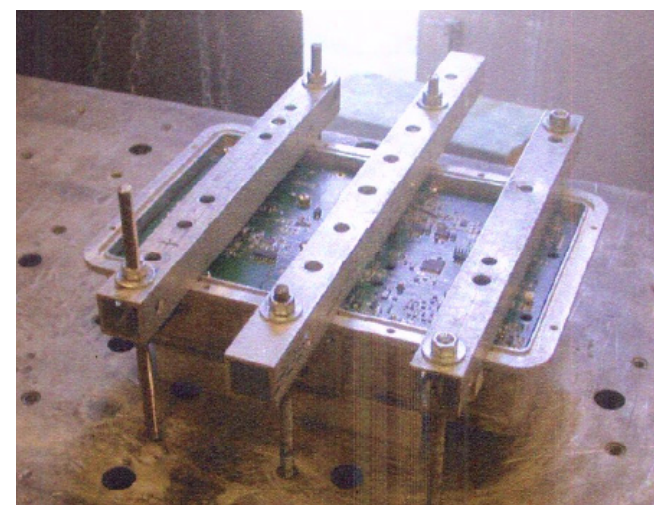


Size and Weight

- Smaller and lighter is better
- Bulkhead mount connectors are large and bulky
- Coolant connections must accommodate high flow rate with low pressure drop
- Sealed construction IP6k9k
- High vibration
- Under hood temperature rating

Long Design Life

- Used every day for 8 hours (powered)
- Driven every day for 2 hours (unpowered)
- Long operating time and high vib/temp
- Control and protection not consistent across OEMs
- Long life, low cost and small size particularly challenging
- 150,000 miles
- 15 years



High Efficiency

- Higher efficiency results in lower losses
 - Lower operating cost
 - Shorter charge time
 - Reduced cooling requirement
 - Higher power density
 - Smaller package size

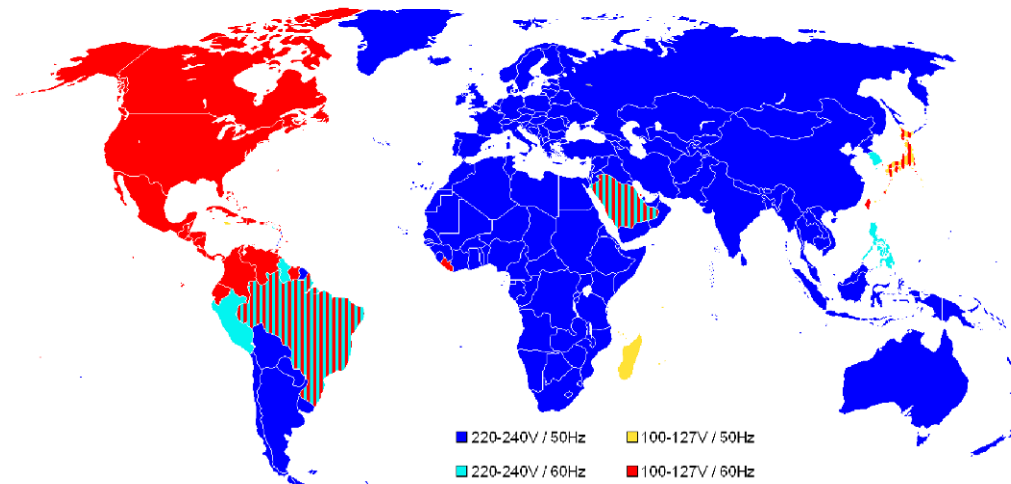
Flexible, Optimized Power Level

Larger battery requires larger capacity charger, yet common outlet is 15A @ 120VAC (North America)

- 8 hour charge from 15A, 120V outlet
 - @ 280Wh/mile: $1200W \text{ max} * 8 \text{ hour} = 34 \text{ mile}$
 - OK for PHEV, but BEV needs more power
- 8 hour charge from 16A, 230V outlet
 - @ 280Wh/mile: $3.3kW \text{ max} * 8 \text{ hour} = 94 \text{ mile}$
- 4 hour charge from 32A, 240V outlet (40A branch)
 - @ 280Wh/mile: $6.6kW \text{ max} * 4 \text{ hour} = 94 \text{ mile}$

Charger must be sized for battery pack, available power, recharge time, etc.

Universal Input, Standards Compliance

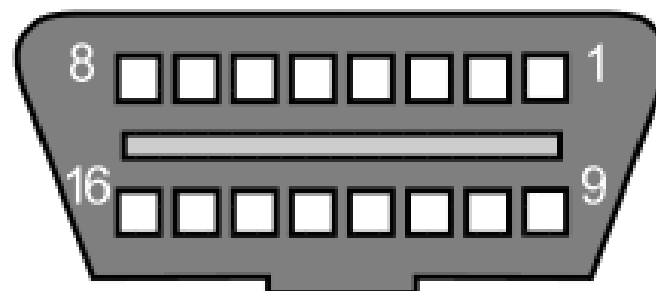


- Efficiency, cooling, EMI, etc. require consistent form factor to meet OEM requirements
- Charge voltage 200 - 450VDC
- Connectors and mounting schemes must be OEM specific
- Design must accept input: 85-265VAC, 50/60Hz
- Local and global standards

Universal Input, Standards Compliance

Automotive

- SAE (i.e. J1772, J2836, J551, J1939, etc.)
- OEM own requirements (i.e. crash test, environmental, etc.)
- Communications (which network?)
- Battery compatibility
- OBD
- Safety
- Size, weight, orientation
- Cooling scheme compatibility



Universal Input, Standards Compliance

Utility/External/Safety

- Emissions/Power quality
- Charge power continuous rating (i.e. 15A branch)
- Reliability/life (emissions component?)
- Communications, V2G, AMI, etc.
- Regulatory agency approvals and regulations (i.e. UL/CSA, IEC, CE, OSHA, etc.)
- Isolation
- Communication schemes

Low Cost

- Charger designed for the life of the vehicle
- No maintenance
- Initially priced as a new product
- Opportunities for cost reduction
 - Integration
 - Reduced requirements
 - Volume

Qualified Supplier

- Manufacturing and support by leading Tier 1 supplier of complimentary products
- Delta-Q supplies technology as Tier Two to Tier One supplier
- OEM receives innovative, proven technology from proven supplier

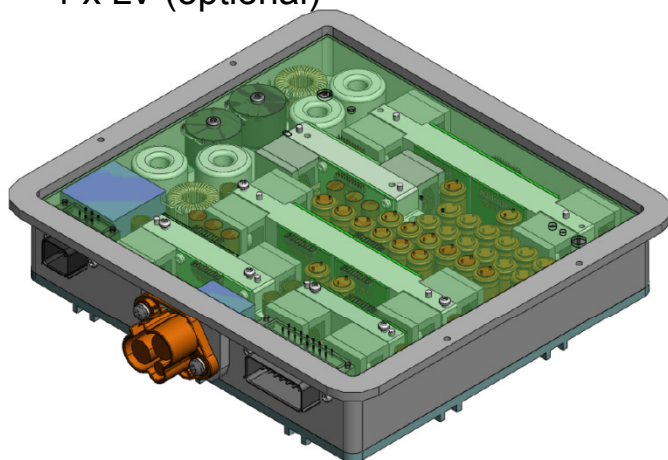
QMX 3.3

- Prototype/evaluation charger shipments to OEMs started 09Q3

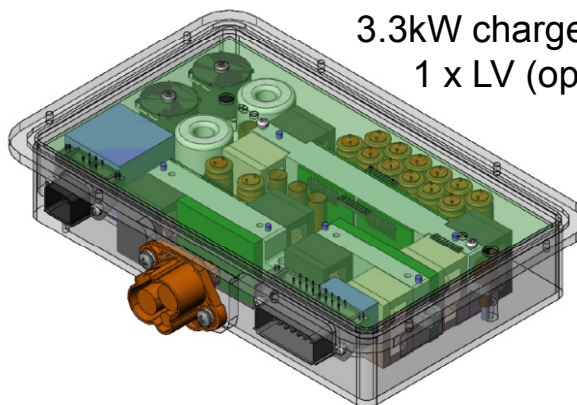


QMX Family

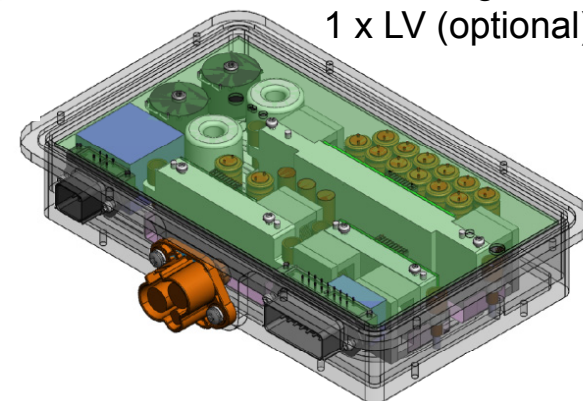
QMX6.6
6.6kW charge modules
1 x LV (optional)



QMX3.3
3.3kW charge modules
1 x LV (optional)



QMX1.65
1.65kW charge module
1 x LV (optional)



Technology Advances

- Flexible power electronics architecture
 - Hardened, designed-once-and-proven modules for power level flexibility
- Extensive “front end” protection to ensure reliable operation from any outlet in the world
 - *based on Delta-Q's 500,000 fielded units*

Automotive Charger Channel



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**Robust automotive
chargers, ready for
worldwide use**

- ✓ Worldwide AC grid experience
- ✓ Extensive Power Electronics Expertise
- ✓ Design for Manufacture (DFM)
- ✓ Validation & Test
- ✓ Manufacturing and Logistics

Conclusion

- Complicated array of diverse requirements
- Various stakeholders and standards
- Chargers are not an ordinary automotive part
- Control schemes and operating modes not consistent across OEMs
- Chargers must come through conventional channels

Thank You!

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