



# High-power low-voltage motor drive

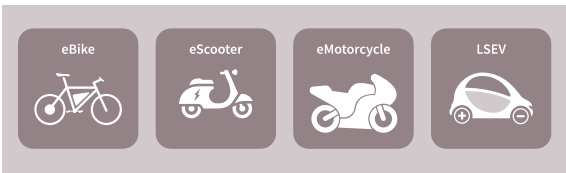
Powering light e-mobility and material handling

High-power low-voltage motor drives power both personal light e-mobility vehicles such as e-bikes, e-scooters, e-motorcycles, microEVs, as well as material handlers such as e-forklifts, delivery vehicles (xDVs), autonomous mobile robots (AMR), automated guided vehicles (AGV), and commercial, construction and agricultural vehicles (CAV). These applications can be collectively referred to as light electric vehicles (LEVs). LEVs have an ever-growing need for highly efficient, intelligent, and powerful motor-drive systems to address requirements such as high speed, high peak, and continuous torque, safety, reliability, and most of all, long battery lifetime. Infineon offers a comprehensive, end-to-end solution for every segment and variation of this diverse market with power levels ranging from 200 W to 50 kW. The **OptiMOS™** and **StrongIRFET2™** MOSFET families form a powerful yet efficient muscle of the system, while the **EiceDRIVER™** gate driver family offers a broad range of both isolated and non-isolated gate drivers. An array of motor control MCUs such as **iMOTION™**, **XMC™** and **AURIX™** along with their software/tools ecosystem, enable quick, easy, and tailor-made implementations of advanced motor control algorithms with necessary safety requirements. The **XENSIV™** current and angle/position sensors enable accurate closed-loop control. Along with an extensive product portfolio, Infineon simplifies and accelerates the design process by offering demonstration, evaluation, and reference boards, simulation models, application notes, comprehensive technical support, and a vibrant [developer community](#).

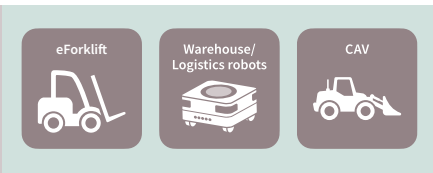
## Features and benefits

Key features	Key benefits
<ul style="list-style-type: none"><li>➤ MOSFETs with best FOMs for drives with low <math>R_{DS(on)}</math>; low <math>Q_{RR}</math>; low <math>\Delta V_{GSth}</math></li><li>➤ Broad and deep microcontroller portfolio enabling varied design approaches (plug n play, optimized custom design), S/W tool libraries, hall and encoder I/F MATH Co-processor, <math>\Delta\Sigma</math> demodulator, functional safety</li><li>➤ Gate drivers with robust isolation, TDI, high/programmable output current, active miller clamp</li><li>➤ Current sensors having high current range, coreless sensing, high resolution, noise immunity and programmability</li><li>➤ Hall switches, angle/position sensors and 3D angle sensors with high accuracy, low jitter and low power consumption</li></ul>	<ul style="list-style-type: none"><li>➤ Extended range/increase in battery life</li><li>➤ Precise motor control</li><li>➤ Enable compact motor drive design</li><li>➤ Quick and easy system-design enabling fast time-to-market</li><li>➤ Rugged, reliable and safe motor drives</li><li>➤ Proven Infineon quality ensuring durability and long life of the system</li></ul>

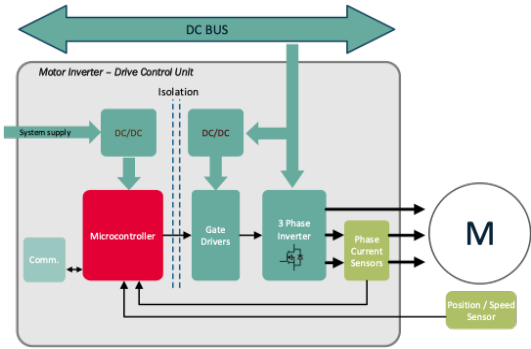
### Personal e-mobility



### Material handling



## Application diagram



Product	Product family
3-phase inverter (MOSFETs)	OptiMOS™, StrongIRFET™
Microcontroller	iMOTION™ IMC 300, XMC™ 1300, 1400, XMC™4100, 4400, 4700
Gate driver	EiceDRIVER™
Position/speed sensor	XENSIV™ angle sensors and Hall switches
Current sensor	XENSIV™ current sensor

## Typical power level of the inverter system: 200 W-4 kW

Component	Product family	Package options	Battery voltage support (V)	Voltage class [V <sub>DS</sub> max]	Representative part numbers	Features
Inverter/ MOSFETs	StrongIRFET™ OptiMOS™	TOLL TOLG TOLT D <sup>2</sup> PAK 7-pin D <sup>2</sup> PAK TO-220 TO-247 SuperSO8	24-36	60	IPT007N06N, IPTG007N06NM5, BSC012N06NS, ISC010N06NM5, IRFS7534, IPB026N06N, IPB010N06N, IRF60SC241, IRFS7537	Low R <sub>DS(on)</sub> and low conduction losses, tight V <sub>GSth</sub> spread for efficient paralleling, low Q <sub>rr</sub> , soft body diode, innovative packages
			36-48	80	IPTG011N08NM5, IPTC012N08NM5, IPT012N08NM5, IPT010N08NM5, IPT012N08NF2S*, IPB015N08NS, IPB017N08NS, BSC019N08NS5, IPP024N08NF2S, IPB024N08NF2S, IPP016N08NF2S, IPP040N08NF2S, BSC037N08NS5, IPB049N08NS	

Component	Voltage class (V)	Configuration	Part number	Source/sink	Package	Features
Gate drivers	60	Three-phase	6EDL7141 NEW	1.5A/1.5A	VQFN-48	Configurable smart gate driver, integrated power management, and current sense amplifiers
	160	Three-phase	6ED2742S01Q*	1A/2A	QFN32	SOI, integrated BSD, trickle charge pumps, power management and current sense amplifiers, RFE
	160	High- and low-side	2ED2742S01G*	1A/2A	DFN10	SOI, integrated BSD, UVLO, separate VSS/COM, thermal pad
	160	Half-bridge	2ED2748	4A/8A	DFN10	SOI, integrated BSD, separate VSS/COM, thermal pad
	200	Three-phase	6EDL04N02PR	0.165A/0.375A	TSSOP-28	SOI, integrated BSD, OCP, enable, fault reporting, UVLO enable
	200	High- and low-side	IRS2005S	0.29A/0.6A	DSO8	V <sub>CC</sub> and V <sub>bs</sub> UVLO, matched propagation delay
	200	High- and low-side	IRS2011S	1/1 A	DSO8	UVLO, MT <sub>ON/OFF, max</sub> =20 ns, 3.3 V-5 V input
	600	High- and low-side	2EDL05N06PF	0.36/0.7 A	DSO8	SOI, UVLO, MTON/OFF, max=60 ns, 3.3-15 V input, BSD
	600	Single high-side	IRS21271S	0.2/0.42 A	DSO8	UVLO, OCP, 3-15 V input, fault reporting
	600	Three-phase	6EDL04N06PT	0.165A/0.375A	DSO-28	SOI, integrated BSD, OCP, enable, fault reporting, UVLO enable

## Typical power level of the inverter system: 4 kW-11 kW

Component	Product family	Package options	Battery voltage support (V)	Voltage class [V <sub>DS</sub> max]	Representative part numbers	Features
MOSFETs	StrongIRFET™ OptiMOS™	TOLL, TOLG TOLT D <sup>2</sup> PAK 7-pin D <sup>2</sup> PAK TO-220 TO-247 SuperSO8	48-72	100-120	IPTG014N10NM5, IPTC015N10NM5, IPT015N10NS, IPT015N10NF2S*, IPB020N10NS, ISC022N10NM6, IPB017N10NS, IPTC030N12N3 G, IPB036N12N3 G, IPP039N10NS, IPB042N10NF2S*, IPP050N10NF2S	Low R <sub>DS(on)</sub> and low conduction losses, tight V <sub>GSth</sub> spread for efficient paralleling, low Q <sub>rr</sub> , soft body diode, innovative packages
			72-96	135-150	IRF150P220, IPT039N15NS, IPTG039N15NM5*, IPTC039N15NM5*, IPB044N15NS, IPT044N15NS, IPB048N15NS, IPT054N15NS, BSC093N15NS5, IRFP4568, IPT063N15NS, IPB073N15NS, IRF7779L2, IPP076N15NS, IRFS4115	

Component	Voltage class (V)	Configuration	Part number	Source/sink	Package	Features
Gate drivers	160 V	High- and low-side	2ED2738S01G*	4/8 A	DFN10 3x3mm	SOI, integrated BSD, UVLO, separate VSS/COM, thermal pad
	200 V	1-ch non-isolated	1EDN8550B	4/8 A	SOT23-6	True differential inputs, with ± 80 V static and ± 150 V dynamic ground-shift robustness, separate SRC/SNK output pins
	500 V	High- and low-side	IRS2110S	2/2 A	DSO-16W	MT <sub>ON/OFF, max</sub> =10 ns, separate power and logic ground, SD pin, 3-20 V input
	600 V	High- and low-side	2EDL23N06PJ	2.3/2.8 A	DSO-14	3.3 V-15 V input, -100 V transient, PGND, SOI, integrated BSD, OCP, UVLO, enable, fault reporting
	600 V	High- and low-side	IRS21867S	4/4 A	DSO8	High current level shift gate driver with low V <sub>CC</sub> operation
	650 V	High- and low-side	2ED2181S06 F/J	2.5/2.5 A	DSO8 (F) DSO-14 (J)	SOI, integrated BSD, 3.3-15 V input, MT <sub>ON/OFF, max</sub> =35 ns, -100 V transient, separate logic and power ground (only J version)

Note: The MOSFET parts listed under various power-levels in the above tables is only for guidance purposes; higher power levels can be achieved even with lower voltage class MOSFETs through paralleling.



## Typical power level of the inverter system: &gt;11 kW

Component	Product family	Package options	Battery voltage support (V)	Voltage class [V <sub>DS</sub> max]	Representative part numbers	Features
Inverter/ MOSFETs	StrongIRFET™ OptiMOS™	TOLL TOLG TOLT	96-144	200	IRF200P222, IPB107N20N3G, IPTG111N20NMM3FD, IRFP4668, IRF200S234, IRFS4127	Low R <sub>DS(on)</sub> and low conduction losses, tight V <sub>GSth</sub> spread for efficient paralleling, Low Qrr, soft body diode, innovative packages
		D <sup>2</sup> PAK 7-pin D <sup>2</sup> PAK TO-220 TO-247	144-200	250-300	IRF250P224, IRF300P226, IPT210N25NFD, IPTG210N25NM3FD, IPB407N30N, IPB600N25N3 G, IRFP4868, IRFB4229, IRFS4229	

Component	Voltage class (V)	Configuration	Part number	Source/sink	Package	Features
Gate drivers	1200 V	1-ch isolated	1EDB8275F NEW	5.4/9.8 A	DSO8	3 kV basic isolation with CT technology, (UL1577), separate SRC/SNK output, UVLO (4 types), CMTI > 300 V/ns
	1200 V	1-ch isolated	1EDI60N12AF	10/9.4 A	DSO8	Short circuit clamping, active shut-down, UVLO, separate SRC/SNK output, 3.3-15 V input
	1200 V	2-ch isolated	2EDB8259F*	5.4/9.8 A	DSO-16	3 kV basic isolation w. CT technology, (UL1577), UVLO (4 types), DIS, STP/DTC, CMTI > 300 V/ns
	1200 V	2-ch isolated	2EDF7275F	4/8 A	DSO-16	1.5 kV functional isolation, high CMTI, UVLO, SLDO, DIS, DTC

## Microcontrollers and sensors for precision control and accurate sensing (power-level agnostic)

Component	Product family	Core/ MaxClock speed	Representative parts	Package	Features
Microcontroller	iMOTION™	Arm® Cortex® M0, 48 MHz	IMC301A-F048, IMC301A-F064	LQFP-48, LQFP-64	UART, SPI, I <sup>2</sup> C, LIN, MATH, 2x ACMP, CCU4
	XMC™	Arm® Cortex® M0, 32 MHz	XMC13xx	TSSOP-16/28/38, VQFN-24/40,	UART, SPI, I <sup>2</sup> C, I <sup>2</sup> S, POSIF, MATH, 3x ACMP, CCU8
		Arm® Cortex® M0, 48 MHz	XMC14xx	TSSOP-38, VQFN-40/48, LQFP-64	UART, SPI, I <sup>2</sup> C, I <sup>2</sup> S, CAN, POSIF, MATH, 4x ACMP, 2x CCU8
		Arm® Cortex® M4F, 80 MHz	XMC41xx	VQFN-48, TQFP-64	UART, SPI, I <sup>2</sup> C, I <sup>2</sup> S, CAN, POSIF, HRPWM, CCU8
		Arm® Cortex® M4F, 80 MHz	XMC42xx	VQFN-48, TQFP-64	UART, SPI, I <sup>2</sup> C, I <sup>2</sup> S, CAN, POSIF, HRPWM, CCU8
		Arm® Cortex® M4F, 120 MHz	XMC44xx	TQFP-64/100	Ethernet, USB, UART, SPI, I <sup>2</sup> C, I <sup>2</sup> S, CAN, POSIF, HRPWM, CCU8
		Arm® Cortex® M4F, 144 MHz	XMC47xx	TQFP-100/144, LFBGA-196	Ethernet, USB, UART, SPI, I <sup>2</sup> C, I <sup>2</sup> S, CAN, POSIF, SD/MMC, CCU8

Component	Product family	Representative parts	Features
Angle/position sensors	XENSIV™ Hall switches (end of shaft/out of shaft)	XENSIV™ TLx4961/68	3-32 V operation, active error compensation, high stability magnetic thresholds, low jitter
	XENSIV™ angle sensor (end of shaft)	XENSIV™ TLI5012	Integrated angle calculation, incremental interface, SPI with 8 Mbit/s, ≤ 1.9° angle error over temperature/life, integrated giant magneto resistance-based angle sensor, 15-bit representation of angle value with 0.01° resolution, bi-directional SSC interface
		XENSIV™ angle sensor	Sin/cos output via analog interface, precise rotation sensing (typ. angle error of 1 deg), very-low current consumption (~2mA), extended magnetic field range up to 100 mT, ISO-26262 (functional safety) compliant option
	XENSIV™ 3D magnetic sensor (end of shaft/out of shaft)	XENSIV™ TLI493D	Enables out-of-shaft angular sensing, ±50 mT to ±160 mT ranges, up to 30.8 LSB12/MT sensitivity, low power mode, low offset and match drift, wake up function
Current sensor	XENSIV™ magnetic coreless current sensor	XENSIV™ TLI4971	±25 A, ±50 A, ±75 A and ±120 A measurement range, 240 kHz bandwidth, low sensitivity error over temperature, galvanic functional isolation up to 1150 V, differential sensing, two independent over current detection outputs, user programmable parameters
		XENSIV™ TLE4972	Analog output, up to ±1000 A measurement range, 210 kHz bandwidth, fast overcurrent detection output with programmable threshold, differential sensing, galvanic isolation between current rail and sensor, user programmable parameters

## Design resources

Low-voltage drives scalable power demoboard platform

XMC™ demonstration and eval boards

XENSIV™ TLE-5501 evaluation kit

XENSIV™ current sensors evaluation boards

[www.infineon.com/pmsm-below-200v](http://www.infineon.com/pmsm-below-200v)

\* Coming soon

For more details on the product, click on the part number, visit [infineon.com](http://infineon.com) or contact our [product support](#).





### System specification exemplar

$V_{bat} = 24 \text{ V}$ , 500 W PMSM motor

Component	Features
MOSFETs	<a href="#">BSC012N06NS</a>
Microcontroller	<a href="#">IMC301A-F048/XMC1302-T038X-0032</a>
Gate driver	6ED2742S01Q*
Position/speed sensor	<a href="#">TLI49611MXTMA1</a>
Current sensor	<a href="#">TLI4971-A120T5-U-E0001</a>



### System specification exemplar

$V_{bat} = 48 \text{ V}$ , 3 kW PMSM motor

Component	Features
MOSFETs	<a href="#">IPTC012N08NM5</a>
Microcontroller	<a href="#">IMC301A-F064/XMC1403-Q048X0200 AA</a>
Gate driver	2ED2738S01G*
Position/speed sensor	<a href="#">TLE5012B E1000</a>
Current sensor	<a href="#">TLI4971-A120T5-U-E0001</a>



### System specification exemplar

$V_{bat} = 96 \text{ V}$ , 6 kW PMSM motor

Component	Features
MOSFETs	<a href="#">IPT039N15N5</a>
Microcontroller	<a href="#">XMC1404-F064X0200 AA</a>
Gate driver	2EDB8259F*
Position/speed sensor	<a href="#">TLE5501 E0002</a>
Current sensor	<a href="#">TLE4972-AE35S5</a>



### System specification exemplar

$V_{bat} = 48 \text{ V}$ , 20 kW PMSM motor

Component	Features
MOSFETs	<a href="#">IPTG014N10NM5</a>
Microcontroller	<a href="#">XMC4700-F100K1536 AA</a>
Gate driver	2EDB8259F*
Position/speed sensor	<a href="#">TLE5501 E0002</a>
Current sensor	<a href="#">TLE4972-AE35S5</a>

