

# Small Signal MOSFETs: Features, Benefits, and Applications

Infineon's portfolio targets a broad range of applications

## Abstract

As the market leader for Power Discretets, Infineon offers one of the most comprehensive [Small Signal MOSFET](#) portfolios in the industry. Infineon is a trusted partner to the top manufacturers of electronic devices in all market verticals, thanks to the highest level of product quality and its reliability as a component supplier.

In expanding the Small Signal MOSFET portfolio, Infineon continues to focus on offering the right solution to its customers by being able to deliver parts in the most challenging of market situations. Infineon's delivery performance is ranked at the top by some of the top-tier manufacturers across all industries as well as distribution partners. The wide range of Small Signal and Small Power MOSFET products is ideal for space-constrained automotive, industrial, and consumer applications such as [battery protection](#), [battery charging](#), [LED lighting](#), load switches, [DC-DC converters](#), level shifters, [low-voltage drives](#), and many more.

This whitepaper presents the key features of these products, the benefits that they bring to the designers, as well as specific application examples.

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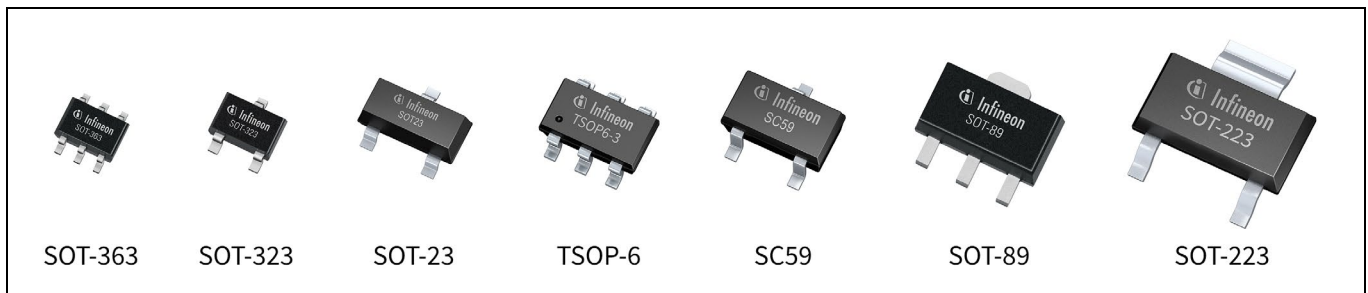
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## 1 Small Signal MOSFET: Definition and key features

At Infineon, the term Small Signal MOSFET refers to products coming in small outline transistor (SOT) packages such as [SOT-223](#), [SOT-23](#), [SOT-323](#), [SOT-363](#), but also including packages such as [TSOP-6](#) and [SC59](#).

A Small Signal MOSFET from Infineon is the same as any other MOSFET with an  $R_{DS(on)}$ , a breakdown voltage, and a current rating. The parts are suitable for low power applications, such as auxiliary circuitry, logic functionalities, switches, and many more. They allow full functionality by saving printed circuit board space. Typical power levels are  $\leq 1$  W.



**Figure 1** Small Signal package portfolio with package outline

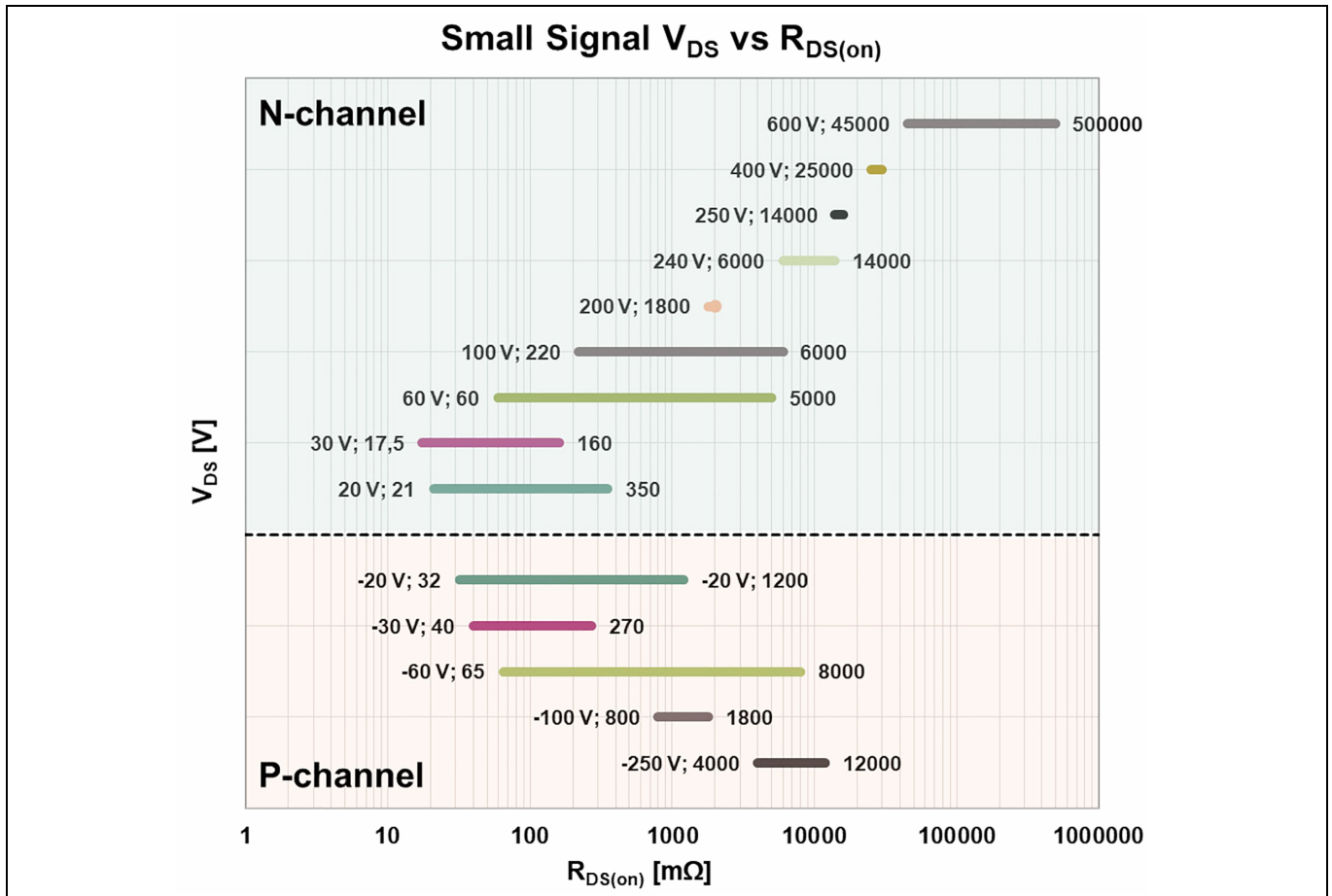
- › N-channel, N-channel depletion mode, P-channel
- › Single, Dual and Complimentary (N+P) devices
- › Four  $V_{GS(th)}$  classes are available for 1.8, 2.5, 4.5, and 10 V gate drive
- › Available in Standard-, Industrial-, and Automotive-quality grades
- › Low leakage currents
- › RoHS compliant and halogen-free

### 1.1 N-channel and P-channel MOSFETs

Infineon's Small Signal portfolio is available in N-channel, N-channel depletion-mode as well as in P-channel. The main difference is related to the construction of the circuit.

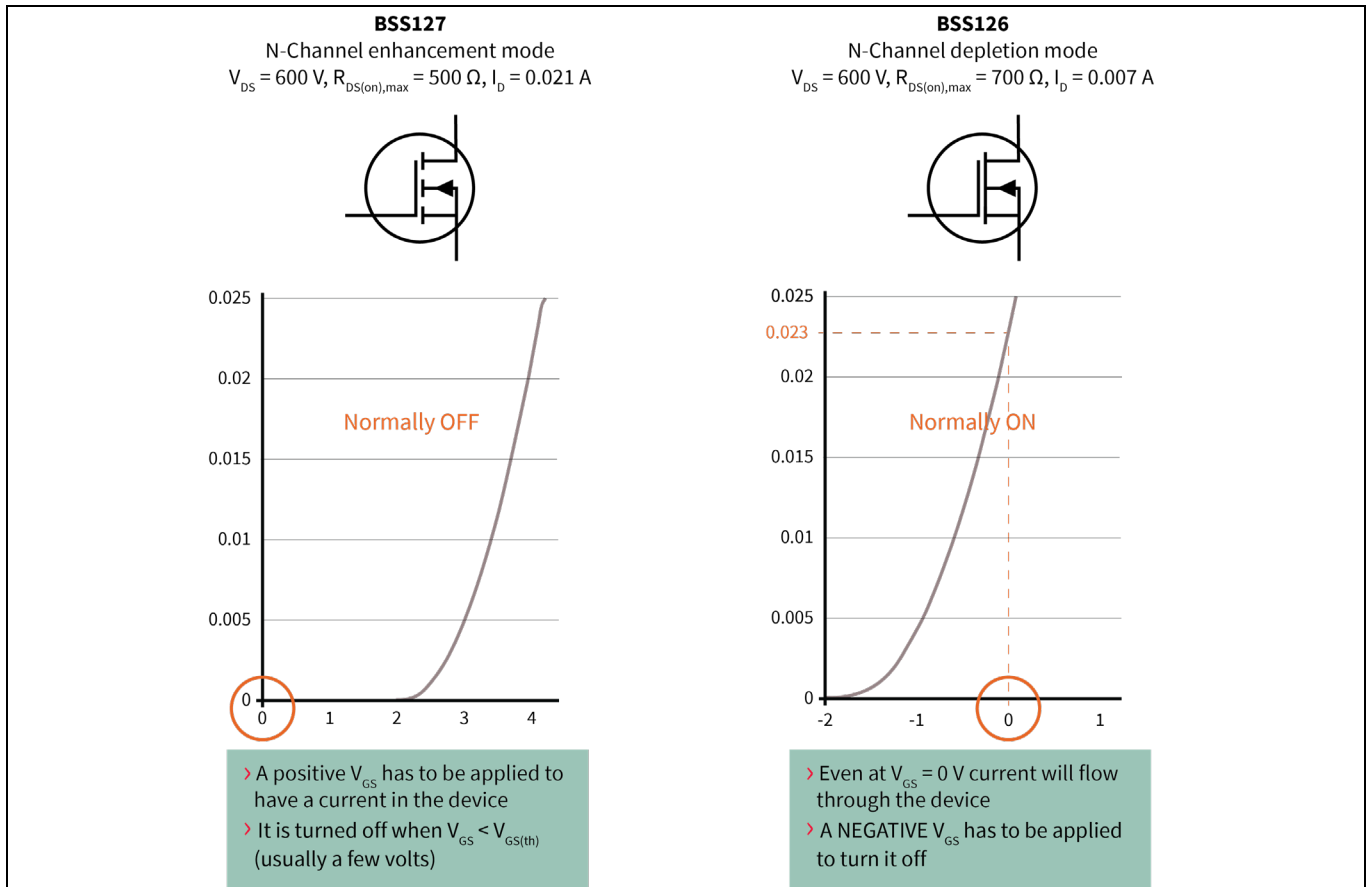
Using an N-Channel MOSFET on the high side requires a complex gate driver circuit with charge pumps or bootstraps. On the other hand, a P-Channel MOSFET requires a very simple gate driver circuit. A few low-cost components such as resistors, a Zener diode, a Small Signal N-Channel MOSFET, or even an NPN transistor are all that is necessary. Thanks to its simple gate driver circuit design, P-Channel MOSFETs are the ideal solution for a high-side switch. It is worth mentioning that the  $R_{DS(on)}$  per unit of area of a P-Channel MOSFET is approximately three times that of an N-Channel, and the high mobility of carriers in an N-Channel MOSFET enables the much lower resistance value.

Figure 2 shows the  $R_{DS(on)}$  range by voltage class in N- and P-channel for Small Signal products.



**Figure 2 Voltage vs. on-state resistance of Small Signal MOSFET portfolio**

Besides N- and P-Channel power MOSFETs, Infineon provides a portfolio for depletion-mode devices.



**Figure 3 Enhancement vs. depletion MOSFET**

Depletion mode MOSFETs are widely used in different applications such as SMPS start-up circuitry, linear regulators, constant current sources, etc.

## 1.2 Four $V_{GS(th)}$ classes are available for 1.8, 2.5, 4.5, and 10 V gate drive

$V_{GS(th)}$  is the gate threshold voltage that defines the minimum gate-to-source voltage required to create a conducting path between the source and drain terminals of the MOSFET.

- > Logic Level (LL – from  $V_{GS} = 4.5 \text{ V}$ ), Super Logic Level (SLL – from  $V_{GS} = 2.5 \text{ V}$ ), and Ultra Logic Level (ULL – from  $V_{GS} = 1.8 \text{ V}$ ) MOSFETs can be driven directly from a microcontroller eliminating the need of an external MOSFET driver in low-frequency applications. Some systems have limited bus voltages, e.g., 5 V, thereby requiring LL/SLL devices.
- > Normal level (NL – from  $V_{GS} = 10 \text{ V}$ ) MOSFETs are used in noisy environments. The elevated threshold voltage prevents a false turn-on of the MOSFET.

### 1.3 Industrial-grade portfolio expansion

Infineon's Small Signal power MOSFET portfolio includes Automotive-, Industrial-, and Standard-qualified products. In particular, the Industrial-qualified portfolio has been recently expanded in both N-channel and P-channel to provide the right quality and reliability to designs that do not require Automotive qualification.

The requirements for introducing the Small Signal Industrial portfolio are to provide an excellent price/performance ratio and broad availability. The new Industrial-qualified parts are direct replacements for some of the most popular automotive-grade Small Signal MOSFETs in the portfolio. By moving to Industrial-qualified components, customers can avoid the capacity limitations and long lead times that the current market is experiencing due to the increased demand for semiconductors coming from automotive suppliers.

**Table 1 Automotive- and Industrial-grade product portfolio**

Polarity	Package	Voltage [V]	Automotive-qualified	Industrial-qualified equivalent	$R_{DS(on)}$ max @ $V_{GS} = 10\text{ V}$ [mΩ]
N-Channel	SOT-23	60	BSS138	BSS138I	3500
			SN7002	SN7002I	5000
		100	BSS123	BSS123I	6000
			BSS169	BSS169I	6000
	250	BSS139	BSS139I	14000	
	SOT-223	600	BSS127	BSS127I	500000
BSP135			BSP135I	45000	
P-Channel	SOT-223	-60		ISP650P06NM	65
			BSP613P	ISP12DP06NM	125
			BSP170P	ISP25DP06NM	250
			BSP315P	ISP75DP06NM	750
			BSP171P	ISP25DP06LM	250
			BSS83P	ISS17EP06LM	1700
		BSS84P	ISS55EP06LM	5500	
		-100		ISP16DP10LM	160
			BSP322P	ISP98DP10LM	980
			BSP316P	ISP20EP10LM	2000
-150		ISP14EP15LM	1380		

## 2 Small Signal and Small Power MOSFET Applications

With an optimal price/performance ratio and small footprint packages, Infineon's Small Signal MOSFETs are the best fit for a wide range of applications and circuits. These include [low voltage drives](#), [linear battery chargers](#), [battery protection](#), load switches, [DC-DC converters](#), reverse polarity protection, and many more. The following sections present application examples for personal care appliances, [battery management systems](#), and [power tools](#).

### 2.1 Personal care appliances

Personal care appliances indicate applications such as oral care (toothbrush, flosser, and whitener), hair care (clipper, shaver, trimmer, epilator), body care (portable massager), and skincare. These devices generally have power consumption between 3-30 W with a motor drive of 12 V power supply. Small Signal power MOSFETs are the perfect solution for the DC motor thanks to price/performance and simplicity features.

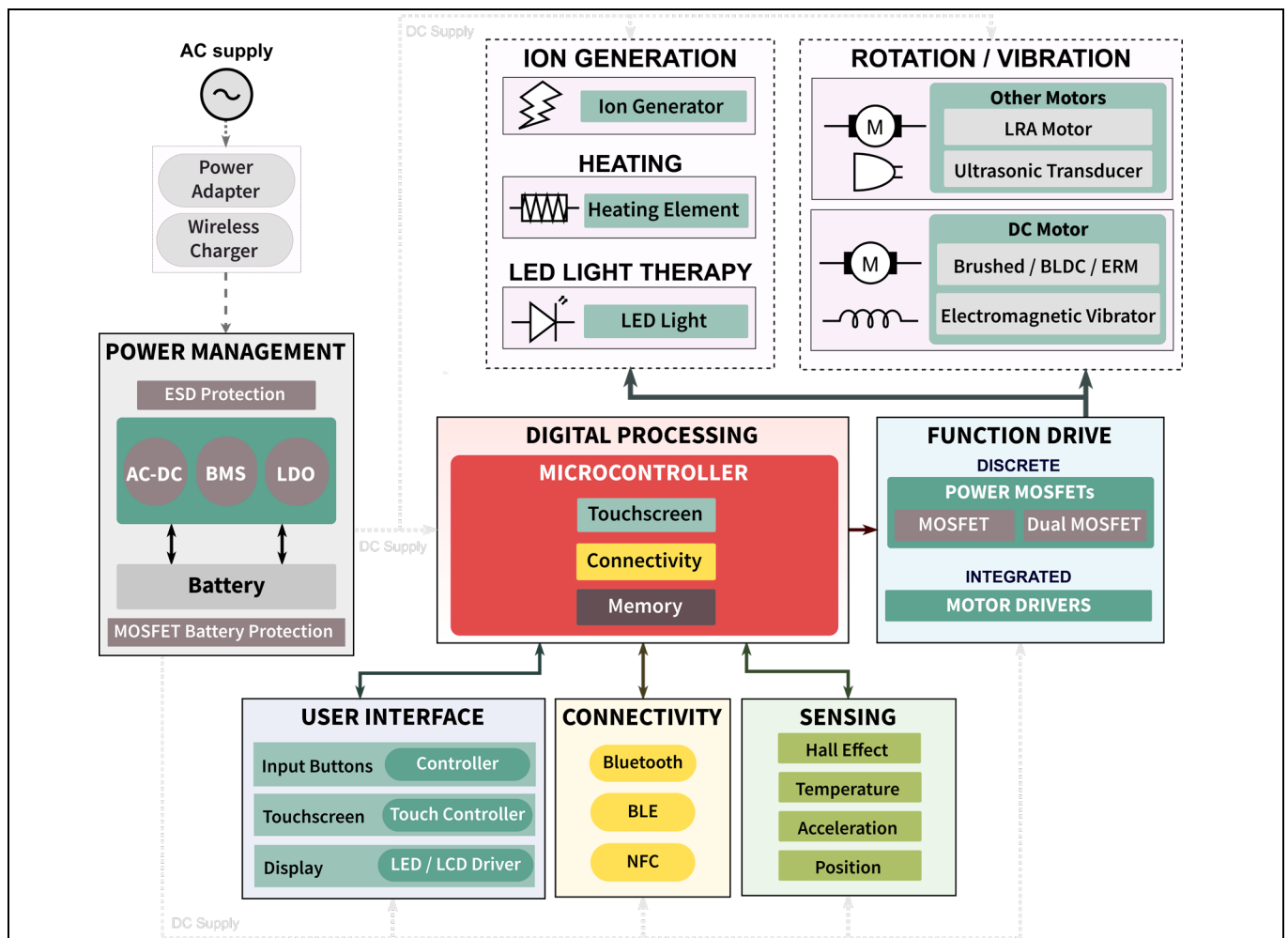


Figure 4 Block diagram of low-power personal care appliance

**Table 2 Infineon's Small Signal MOSFET product portfolio for personal care applications**

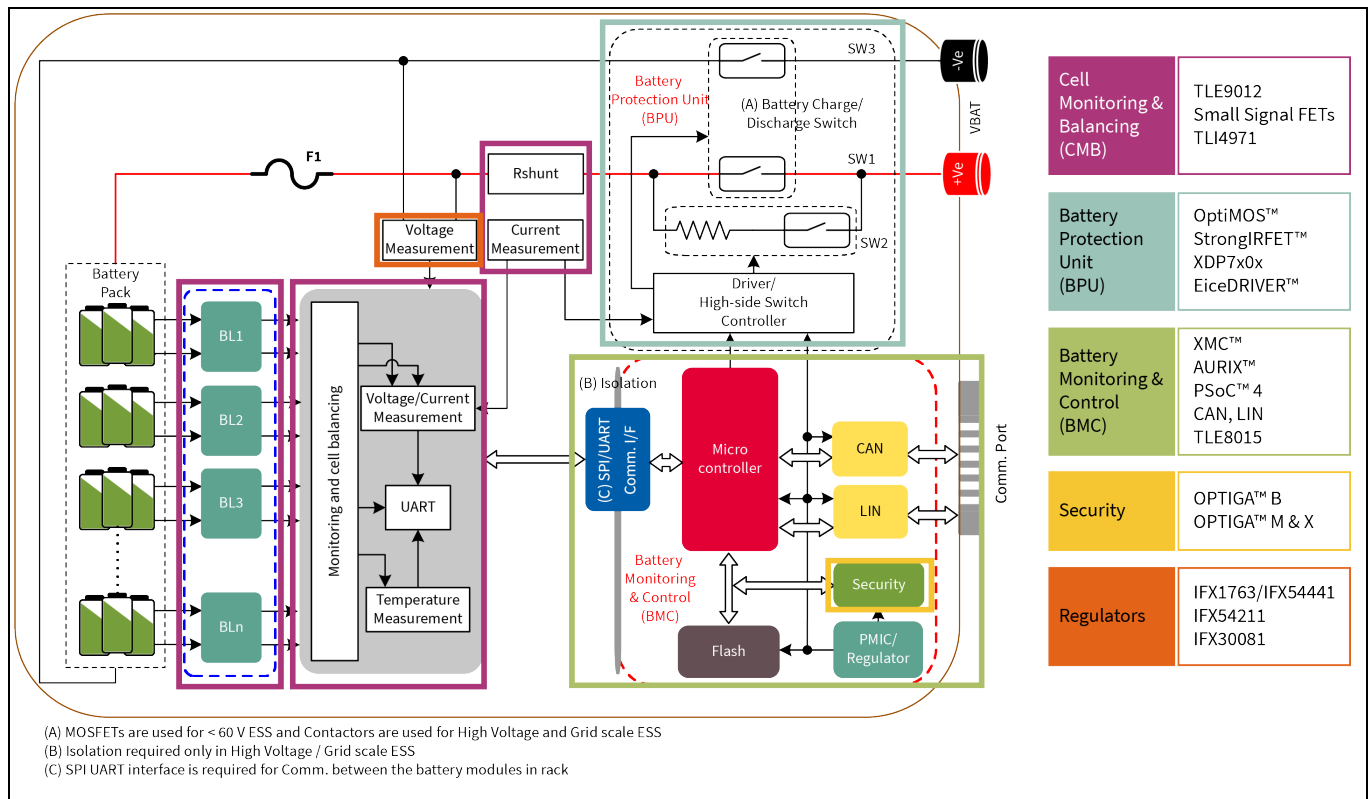
Polarity	Voltage [V]	Package	V <sub>GS(th)</sub> class	Product name	R <sub>DS(on)</sub> max [mΩ]
N-channel	20	SOT-323	ULL	BSS816NW	160
			SLL	BSS214NW	140
		TSOP-6	SLL	BSL202SN	22
				IRLM2002	30
				IRLMS1902	100
		SOT-23	ULL	BSS806NE	57, ESD
				BSS806N	57
			SLL	IRML2502	45
				BSS205N	50
				BSS214N	140
		IRML2402	250		
		LL	IRLM6246	46	
	30	TSOP-6	LL	IRLTS6342	17.5
				IRLMS1503	100
			NL	IRFTS8342	19
		SOT-23	LL	IRLML0030	27
				IRLML6344	29
				BSS306N	57
				IRLML6346	63
IRLML2030				100	
BSS316N				160	
IRLML2803				250	
P-channel	-20	TSOP-6	SLL	IRLTS2242	32
				BSL207SP	41
				IRLMS6802	50
				BSL211SP	67
				IRLMS6702	200
		SOT-23	SLL	IRLML2244	54
				IRLML6402	65
				IRLML2246	135
	-30	TSOP-6	LL	BSS215P	150
				IRFS9342	40
				BSL307SP	43
		SOT-23	LL	BSL308PE	80, ESD
				IRLML9301	64
				BSS308PE	80, ESD
				IRLML5203	98
				BSS314PE	140, ESD
				BSS315P	150
IRLML9303	165				
IRLML5103	600				

## 2.2 Battery management systems

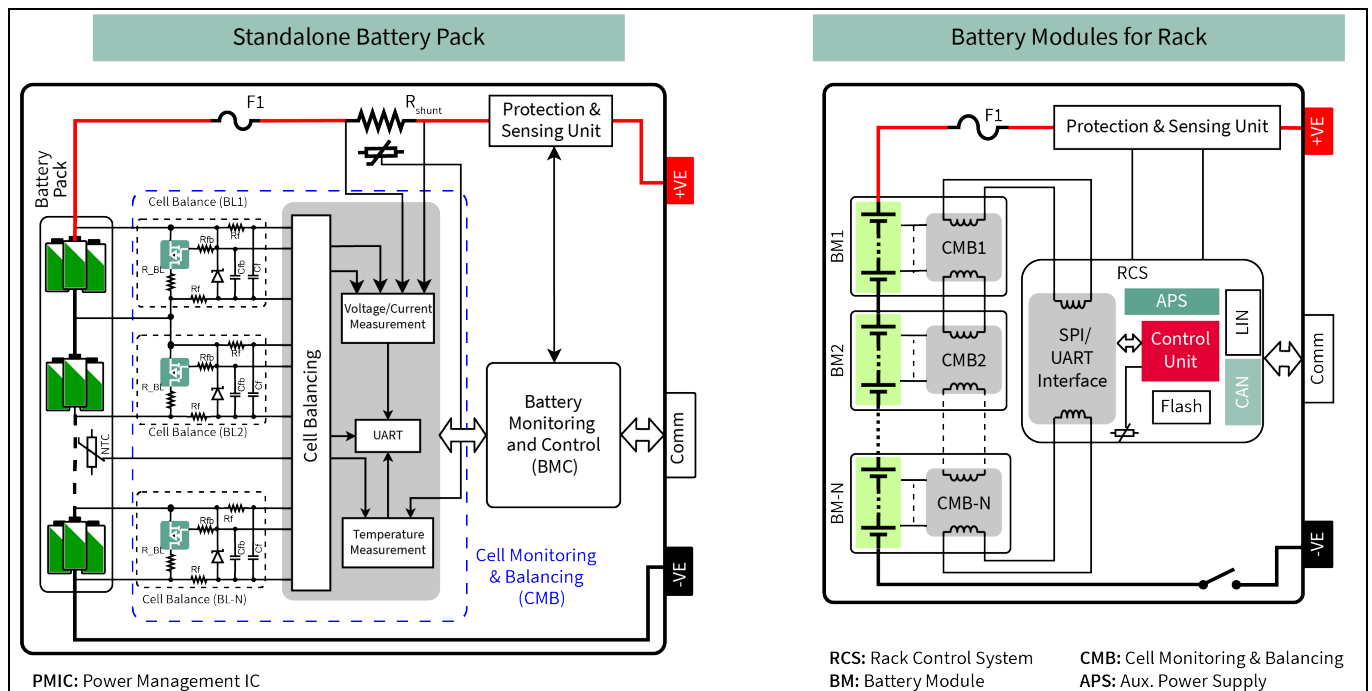
Battery management systems (BMS) are electronic control circuits that monitor and regulate the charge and discharge of batteries. These can be found in numerous applications such as [power tools](#), e-scooter, [light electric vehicles](#), etc. Their main task is to ensure the optimal use of the residual energy present in a



battery. In order to avoid loading the batteries, **BMS systems** protect the batteries from deep discharge and over-voltage, which are results of extreme fast charge and extreme high discharge current.



**Figure 5** Block diagram of a battery management system (BMS)



**Figure 6** Standalone battery pack (a) and battery modules for a rack (b)

Requirements such as space constraints, equalizing current between 0.5 A to 2.5 A, and compact solution with smaller PCB footprint are making Small Signal MOSFETs the perfect choice for cell monitoring and balancing (CMB).

Table 4 below shows some of the devices most commonly used for this application. These devices come in packages such as SC59, SOT23, SOT323, TSOP6, and SOT363 from 20 up to 600 V.

**Table 3 Infineon's Small Signal MOSFETs product portfolio for BMS**

Package	Type	Equalizing current	20 V products	30 V products
SC59	Single	< 2.0 A	BSR802N BSR202N	
SOT-23		> 1.5 A	BSS205N BSS806NE BSS214N	IRLML0030 BSS306N BSS316N
SOT-323		< 0.8 A	BSS214NW BSS816NW	
TSOP-6		< 2.0 A	BSL202SN IRLMS2002 IRLMS1902	
SOT-363	Single	< 1.0 A	BSD2145SN BSD235N BSD840N	BSD316SN
	Dual	< 0.5 A	BSD235C	

### 2.3 Power tools – Brushless DC (BLDC) motor (discrete)

Within battery-powered applications such as in power tools ([brushless DC motor – BLDC](#)), Small Signal N-and P-Channel MOSFETs can be used in the motor control inverter. When broad availability at distribution partners, excellent price/performance ratio, and standard footprints such as SOT-23 are required, Small Signal MOSFET packages are better for low-power control and drive circuitry than PQFN packages (such as SuperSO8, PQFN 3.3x3.3, and PQFN 2x2). Depending on the DC motor drive system requirements, Infineon offers a broad portfolio of both Industrial- and Consumer-grade products that address different price/performance ranges.

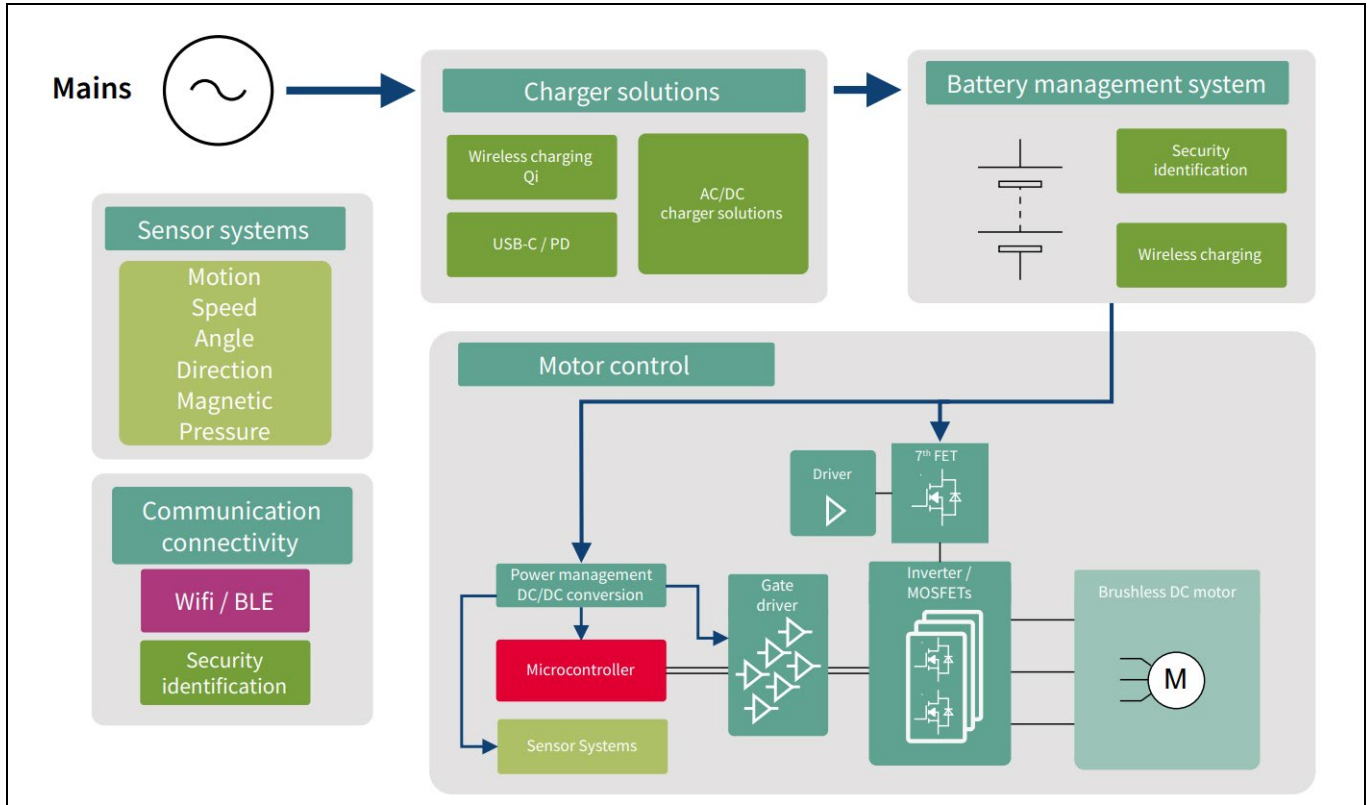


Figure 7 Block diagram of brushless DC (BLDC) motor power tool

Table 4 Recommended Small Signal product portfolio for Brushless DC motor

Voltage class [V <sub>DS max</sub> ]	Package	Part number	R <sub>DS(on)</sub> @ V <sub>GS</sub> =10 V [mΩ]	Inverter [V]
20	SOT-23	IRLML6244	21	12
	TSOP-6	BSL202SN	22	
	SC59	BSR802N	23	
30	SOT-23	IRLML00130	27	18
		BSS306N	57	
40	SOT-23	IRLML0040	56	36
	SOT-89	BSS606N	60	
60	SOT-23	IRLML0060	92	48
		BSS138I	3500	
	SOT-23	IRLML0010	220	
100	SOT-23	BSS123I	6000	12
	SOT-223	BSP373N	240	
-20	TSOP-6	BSL207SP	41	18
	SOT-23	IRLML2244	54	
-30	SOT-23	IRLML9301	64	18
		BSS308PE	80	

### 3 Conclusion

Striving to serve all customers by offering the right products and boasting one of the industry's broadest portfolios, Infineon's Small Signal MOSFETs address a broad range of applications and meet the requirements of general-purpose MOSFETs such as:

- > Availability (very competitive lead time)
- > Competitive pricing
- > Ease of use
- > Convenient selection and purchasing at the distribution partners
- > High-quality choice (Automotive, Industrial and Consumer grade)

Furthermore, Infineon's continued investment in manufacturing capacity ensures a reliable supply of Small Signal MOSFETs to its customers even in the most challenging market situations, making Infineon the trusted partner of choice to the leading global electronics manufacturers

For more information, visit us at [www.infineon.com/smallsignal](http://www.infineon.com/smallsignal)



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