# Solutions for Energy Storage Systems (ESS)

26th April, 2022

Energy storage is an integral component of electricity generation, transmission, distribution as well as consumption

Before-the-Meter		Behind-the-Meter
› Conventional and renewables generation combined with ESS (stationary ESS)	› Transmission and distribution system with bulk ESS (stationary / mobile ESS)	› Roof top PV, UPS, V2G (stationary / mobile ESS)

Generation
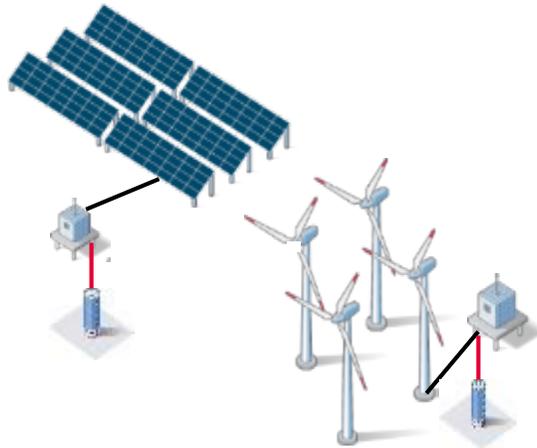
Transmission
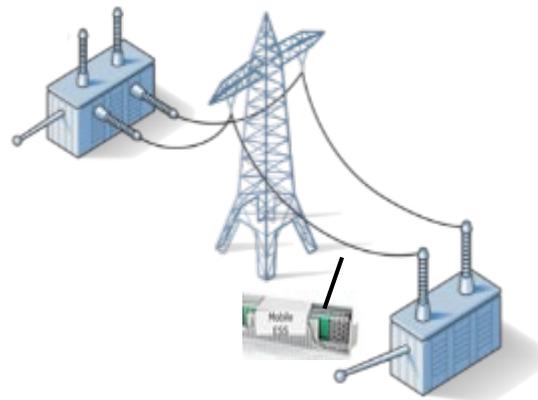
Consumption

Bulk storage, substation, utility wind & utility photovoltaic (PV)

Commercial, residential PV & charging stations

On a high level Energy Storage Systems can be categorized in…

Behind-the-Meter	Before-the-Meter		

Commercial & residential

Intermittent renewables

Transmission capacity constraints

Grid reliability & stability

› Installed in offices, factories and supermarkets mostly for self consumption

› Excessive non self consumed energy generated by rooftop PV is stored in batteries for later consumption

› Boom in wind and solar PV leading to massive weather-dependent fluctuations and distributed generation, hence mismatch of supply and demand is growing

› ESS is needed to smooth-out this fluctuations

› Growing demand on electricity, especially during peak periods (e.g. aircon use at noon etc.), stretching grids to the limit

› Unstable grids and full-blown blackouts due to natural disasters and technical problems in ageing infrastructures

› Through ESS grid reliability and stability can be ensured even

Bulk storage

Substation

Utility wind

Utility PV

Commercial & residential PV

| 0.5 MW | 1 MW | 1.5 MW | 2 MW | 2.5 MW | 4 MW | 4.5 MW | 10 MW |
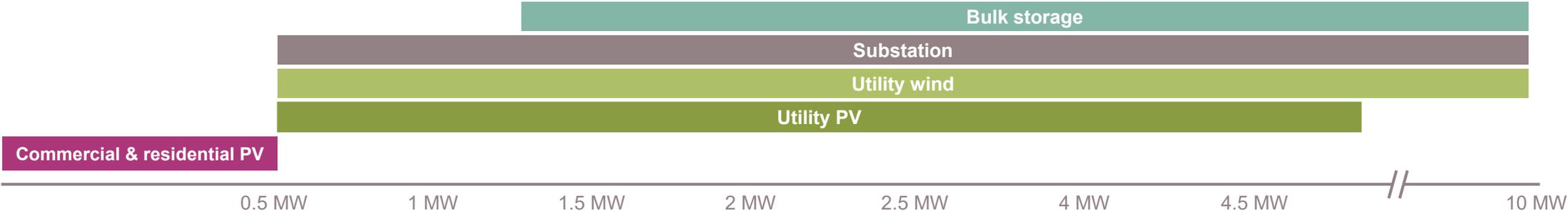
Countries around the world look to decarbonize their power sectors

Annual energy storage installations (GW) [1]

CAGR(20-30): 14%

[GW]
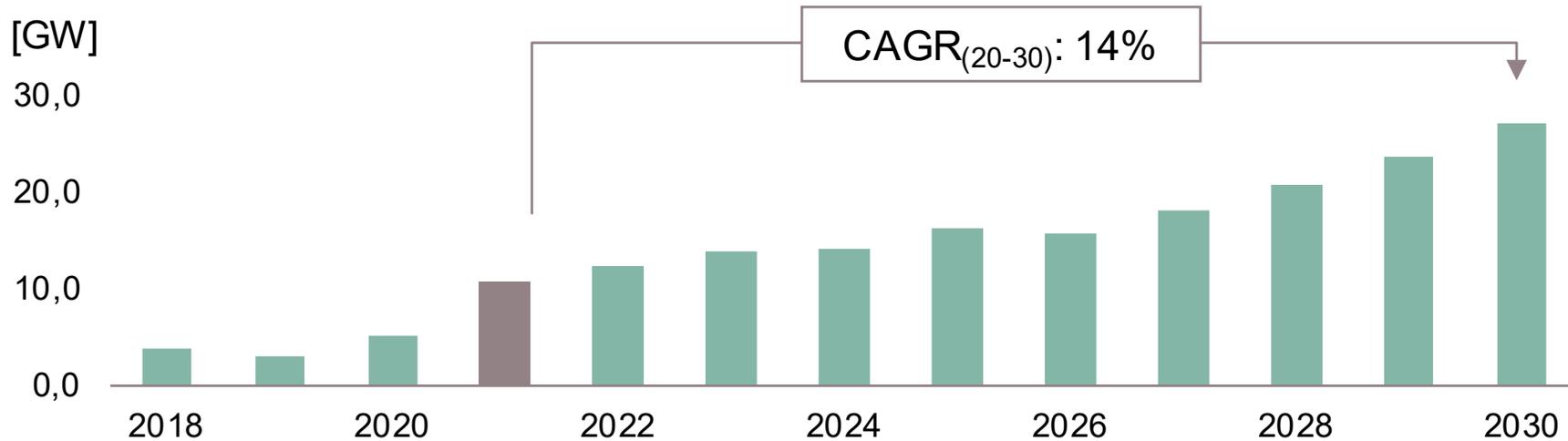
› Global **power conversion** system shipments are predicted to grow to reach over **11 GW** in 2025

› The **front-of-the-meter** segment is predicted to account for **62%** of total shipments in 2025 and will reach **>7.0 GW**

› Significant demand increase in United States due to strong uptake in utility-scale solar plus storage

Source: 1) IHS Markit, "Grid-connected Energy Storage Market Tracker H2 2020", January 2021

Basic overview of Energy Storage Systems (ESS)
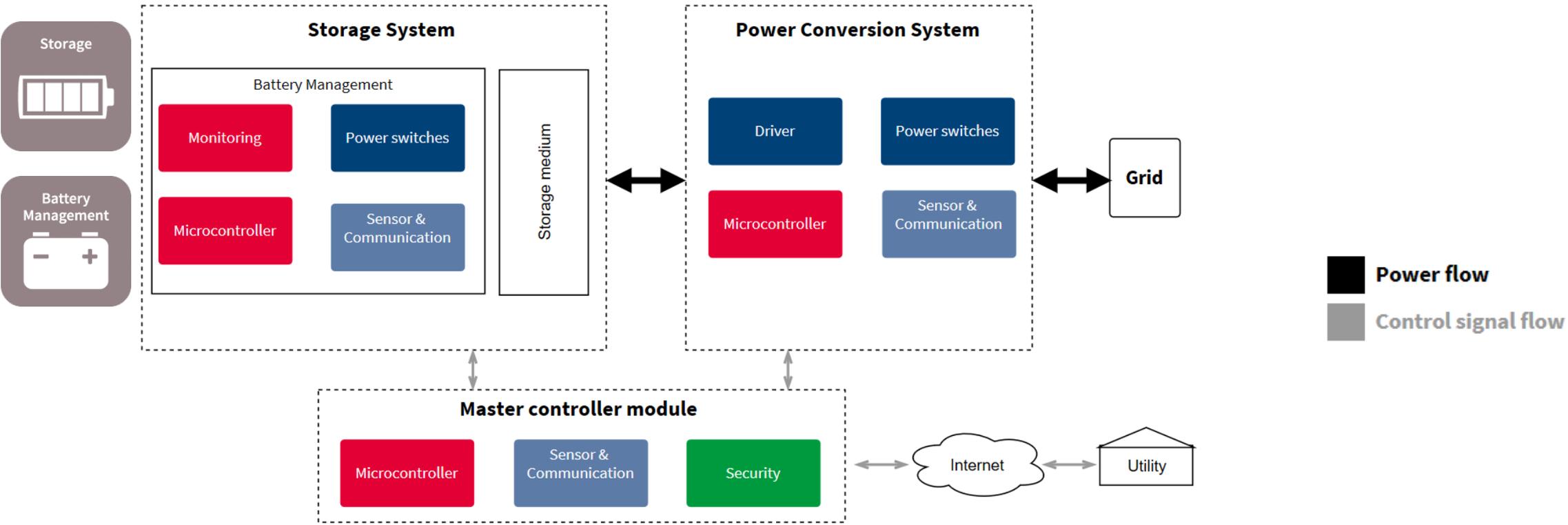
Energy Storage Systems – Infineon's wide array of offerings

Battery/ Energy Storage Media

Monitoring and Balancing IC
Protection FETs
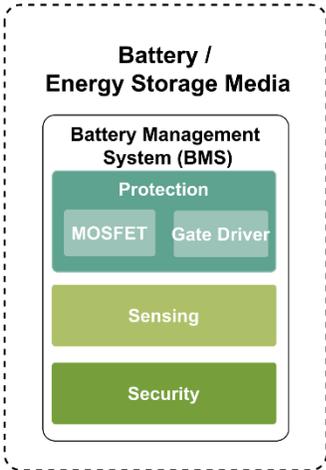
Auxiliary Power Supply

CoolSET™
CoolSiC™

Current sensor

XENSIV™

**Security**

OPTIGA™

Battery / Energy Storage Media

Battery Management System (BMS)
- Protection
  - MOSFET
  - Gate Driver
- Sensing
- Security

DC/DC
- 48 V Battery Voltage
  - CLLC
  - ZVS PSFB
- 150 V to 250 V Battery Voltage
  - CLLC
  - DAB
  - ZVS PSFB
- 251 V to 750 V Battery Voltage
  - DAB
  - ZVS PSFB

DC/AC
- up to 10 kW
  - CCM Totem Pole
  - NPC / ANPC
  - B6
- 10 kW to 100 kW
  - NPC / ANPC
  - Vienna Rectifier
- 100 kW to 250 kW
  - 2-Level
  - 3-Level ANPC
- 250 kW to 1000 kW
  - 2-Level
  - 3-Level ANPC
- > 1 MW
  - 2-Level
  - 3-Level NPC1

Grid / Load

Gate Driver
- MOSFET Gate Driver
- CoolSiC™ Gate Driver
- IGBT Gate Driver

Current Sensor

Current Sensor

Auxiliary Power Supply

Microcontroller

Communication to user

Human-Machine-Interface (HMI)

Security

Discretes and modules MOSFET / SiC / IGBT

Discretes	Modules
CoolMOS™	Easy
OptiMOS™	62 mm
CoolSiC™ MOSFET	EconoDUAL™
CoolSiC™ Schottky diode	PrimePACK™
CoolSiC™ Hybrid Discretes	
TRENCHSTOP™ IGBT	

Gate Driver

EiceDRIVER™

Microcontroller

XMC™
AURIX™

Infineon's power solution offerings for Energy Storage Systems

	≤ 10 kW	10 – 100 kW	100 – 250 kW	250 – 1000 kW	> 1 MW module solutions
PCS — Discrete solutions	CoolMOS™ 7, OptiMOS™, Cool SiC™	IGBT TRENCHSTOP™ 5/6 HighSpeed3; CoolMOS™ 7, Cool SiC™	Multilevel solution; OptiMOS™	Multilevel solution; OptiMOS™	Module solution is recommend
PCS — Module solutions	Discrete solution is recommended	Easy CoolSiC™; Easy 1B / 2B	Easy CoolSiC™; Easy 3B / 4B	PrimePACK™; EconoDUAL™; 62 mm	PrimePACK™
BMS		Monitoring IC, OptiMOS™, CoolMOS™ 7			

CoolSiC™ helps to reduce energy losses leading to some extra energy, available when needed

Advantages of SiC

As the battery bank makes up the major portion of the total system costs for Energy Storage Systems (ESS), a change from super-junction MOSFET to 1200 V CoolSiC™ MOSFET can lead to approx. 2% extra energy without increasing battery size

Our CoolSiC™ MOSFET 1200 V cutting losses by 50% for extra energy

# Coupling topologies for residential Energy Storage Systems

There are two main system coupling topologies for residential ESS, which usually come along with PV installations. Those can be either AC coupled systems or DC coupled
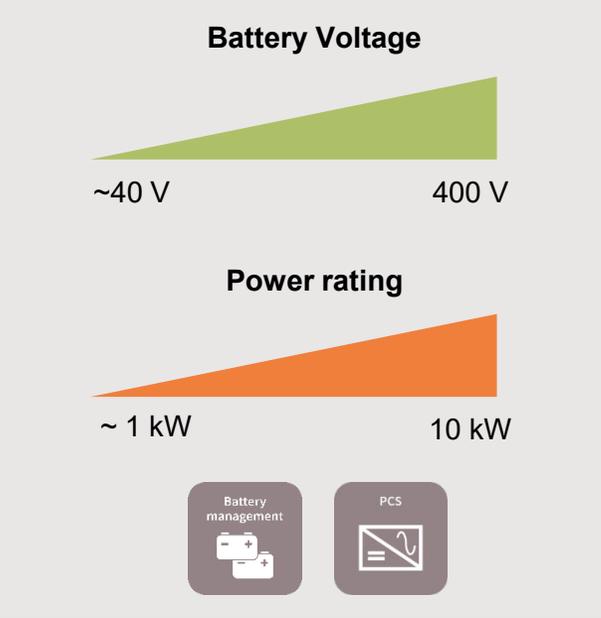
Battery Voltage

~40 V — 400 V

Power rating

~ 1 kW — 10 kW

Battery management | PCS

AC coupled

Photovoltaic panels — MPPT DC-DC — DC-AC PV Inverter — Load — Public Grid

Battery — DC-AC Battery Inverter

DC coupled

Photovoltaic panels — MPPT DC-DC — DC-AC Inverter — Load — Public Grid
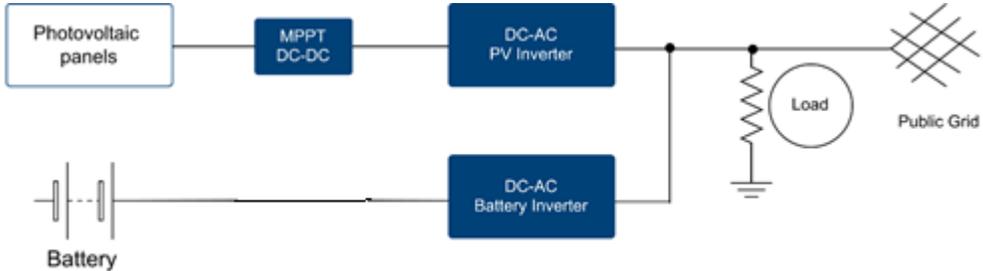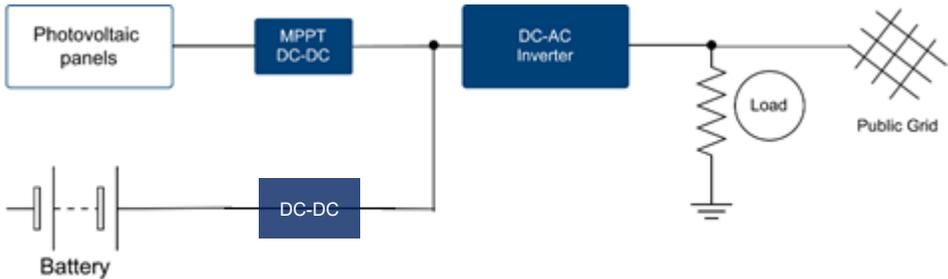
Battery — DC-DC

Infineon's suitable solutions for different topologies in the range from > 10 kW and <125 kW

Topology	Features and Infineon's offerings
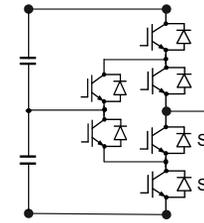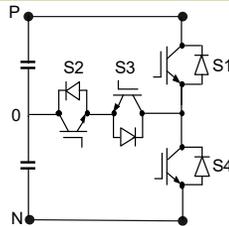
2-level	**AC coupled**
	
	• Battery voltage <1000 V
	    • CoolSiC™ module 1200 V half-bridge (2-level)
	    • Easy CoolSiC™ 3-level (3-level NPC2)

3-level ANPC	

3-level NPC2	• Battery voltage 1200 V, 1300V
	    • 1700 V half-bridge module
	    • 3-level ANPC module

Bi-directional DC-DC	**DC coupled** • Battery voltage <1000 V: CoolSiC™ module 1200 V

Infineon's suitable solutions for different topologies in the range from >125 kW and up to 2 MW

Topology	Features and Infineon's offerings
3-level NPC1	• Battery voltage 1000 V, 3-level NPC1 • 62mm, EconoDUAL™ 3
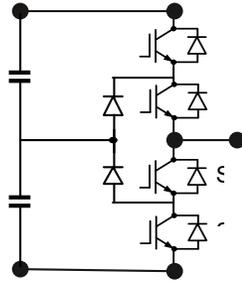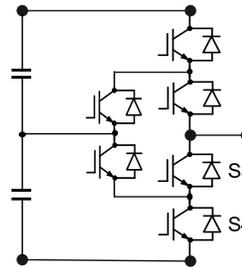
3-level ANPC	• Battery voltage 1500 V, 3-level ANPC
	  • Easy 3B
	  • 62 mm
	  • EconoDUAL™ 3
	  • PrimePACK™ 3. PrimePACK™ 3+
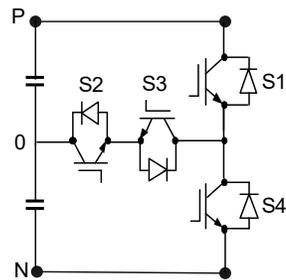
3-level NPC2	• Battery voltage 1500 V, 3-level NPC2 • PrimePACK™ 3+

Discrete 1200 V CoolSiC™ MOSFET TO-247 3 and 4 pin

Application spaces

Solar

Storage

EV-Charging

Industrial SMPS

UPS

AUX power

Drives

CAV
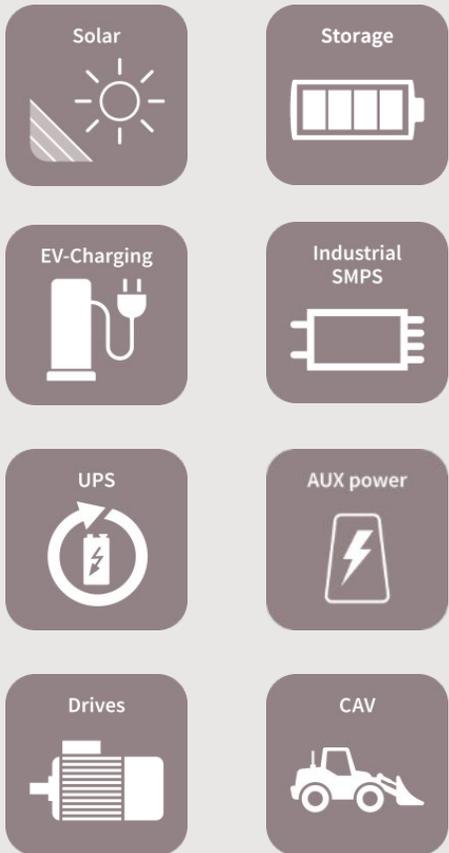
Advanced features

1200 V CoolSiC™ MOSFET:

Higher conversion efficiency and increased switching frequency, enabled by

CoolSiC™

› Lowest RDS(on) in TO247 for highest power density

› Low and temperature independent switching losses

› Threshold-free on-state → no Vce(sat)

› Intrinsic diode with low reverse recovery charge

› Wide gate-source voltage range from 15 V to 18 V

› Benchmark gate threshold voltage, VGS(th) = 4.5 V

› -5 to 0 V turn-off gate voltage for easy and simple gate drive

› Robust body diode rated for hard commutation

› Robustness levels equivalent to silicon IGBTs, through e.g. superior gate oxide reliability

CoolSiC™ MOSFET for ANPC topology in Easy 2B package with improved Si diodes
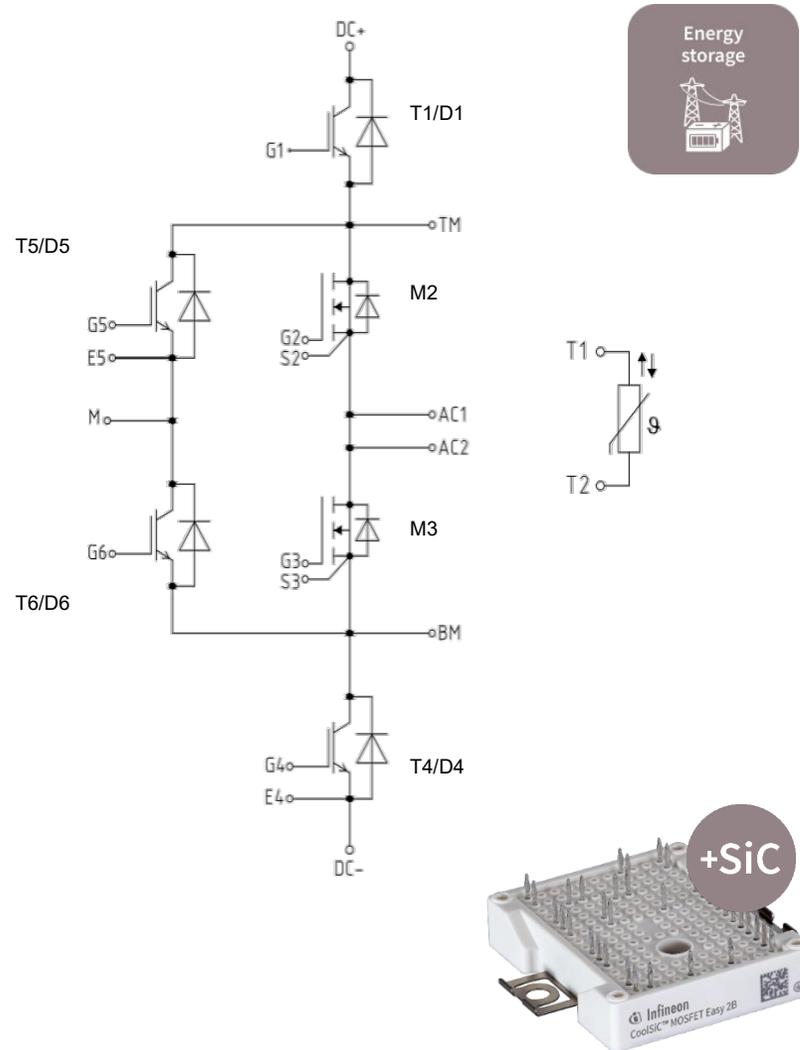

BoM	
M2/M3	1200 V CoolSiC™ MOSFET: 11 mOhm
T1/T4/T5/T6	1200 V IGBT: 100 A Trenchstop 7
D1/D4/D5/D6	1200 V Diode: 100 A Emitter controlled diode 7

› ANPC allows optimal integration of CoolSiC™ MOSFET

› IGBTs are optimized for lowest conduction losses

› Increased Si diode current rating

› No external SiC FWD are needed

› Power losses independent of power factor

› Full 1500Vdc capability using 1200V switches

Sales name	Description
F3L11MR12W2M1H_B74	3-level ANPC Inverter Phase Leg Module

Every Switch Needs A Driver - The right driver makes a difference
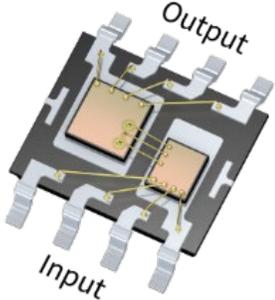
EiceDRIVER™ Enhanced

Up to 2300 V, 9 A
DESAT, Miller clamp

Rich feature-set for advanced protection:

- **F3 (1ED332x):** Cost effective solution with DESAT
- **X3 Analog (1ED34xx):** Best-in-class DESAT accuracy, Analog Configurability
- **X3 Digital (1ED38xx):** I2C configurable enabling predictive maintenance

www.infineon.com/gdenhanced

EiceDRIVER™ Compact

Up to 2300 V, 18 A
Miller clamp, 2-level slew-rate-control

Reduced feature-set and easy to design-in:

- **X3 Compact (1ED31xx):** easy to design & cost effective
- **2L-SRC Compact (1ED32xx):** EMI & switching loss optimization

New products with Reinforced isolation (UL 1577 and VDE-11)

www.infineon.com/gdcompact

TLx4971 Family – Industrial current sensor

Key features **industrial current sensor**

Key value

Multiple Options

The TLx4971 offers **broad flexibility** as many settings can be optimized by customers in the application. Additionally pre-programmed devices are available

> **8 different variants each** 120A, 75A, 50A and 25A **(UL and non-UL)**

Application range

A **bandwidth of 240kHz**, the intrinsic linearity and the very low insertion **resistance of 220 µΩ and less than 1nH inductance** allows a wide range applications, in special **GaN and SiC applications**

> **Wide range of applications**

System compatibility

Stray field robust design with differential measurement of magnetic field allows **accurate measurement** with parallel or multiple current rails

> Optimized for **parallel measurement** e.g. multiple phases

Cost optimization

Reduced BOM cost due to two integrated OCD (Over-Current Detection) pins with less than 1µs reaction time and a small **8x8mm power package**

> **Lower costs** due to **less external components** and **small package size**

Robust design

Enables galvanic isolated measurement for **high voltage** and **high current applications** without heat sink due to the **superior thermal heat dissipation**

> **Galvanic isolation** plus outstanding **thermal performance**

Battery Management Systems

Key functionalities

- 🔗 Protection
- 📈 Performance optimization
- ⚙️ Battery state calculation
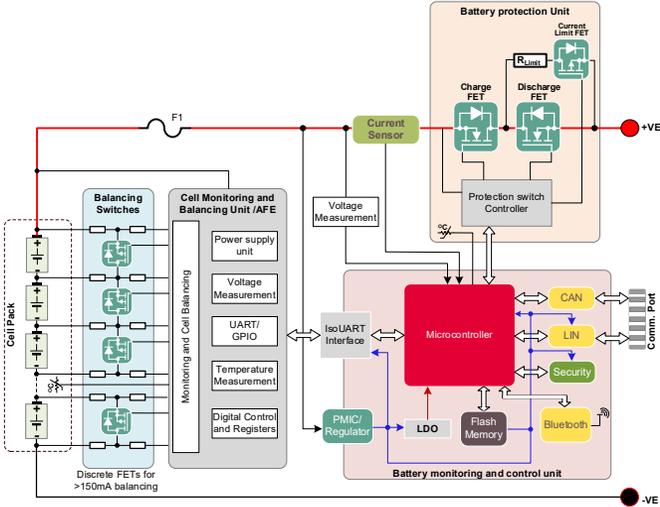
BMS functions

Battery protection				Cell monitoring and balancing (CMB)			
Over charge / Deep discharge	Inrush current	Short circuit	Thermal management	Cell voltage monitoring & balancing	Temperature monitoring	Battery pack voltage monitoring	Current monitoring
Battery monitoring and control (BMC)				Security		Logging	Regulators	Communication	
Fuel gauging	SOH	SOC	Inter-communication	Authentication	Encryption	Data storage	Voltage regulators	PMICs	Wired	Wireless

BMS Offerings

OptiMOS™ 3/5/6 & StrongIRFET™
› Wider safe operating area (SOA)
› Cheaper and more effective parallelization solutions
› Up to 250 V MOSFET protection solutions

EiceDRIVER™ – 2ED4820-EM
› Faster reaction time (~ 10 µs)
› Integrated bidirectional high/low side current sense amplifier saves PCB space and placement cost

TLE7368-xE TLE6368G2
S6BP50x: 3 – Ch PMIC
S6BP401A: 6 – Ch Advanced PMIC

IFX1763 / IFX54441 Family

SEMPER™ NOR flash SEMPER™ secure flash

PSoC 4
› 32-bit MCU Subsystem
› 48-MHz Arm® Cortex®-M0+ CPU
› Flash: Up to 256 KB flash
› RAM: 32 KB SRAM
› Up to 2 CAN
› USB / Up to 4 serial Channels

XENSIV™ TLI4971
› High measurement range (25-120 A)
› Accurate and stable measurement
› Less than 1 nH parasitic inductance

OPTIGA™ Authenticate IDoT

TLE9012/5 and Digital Isolators ISOFACE™

Central diagram nodes: BMS (center), RAM, Power MOSFET, Gate Driver, Micro-controller, Current Sensors, PMICs, VREG, Security, BMS IC

Benefit from Infineon's comprehensive portfolio to solve your Energy Storage Systems design requirements

Reliable products

Complete offering

System expertise
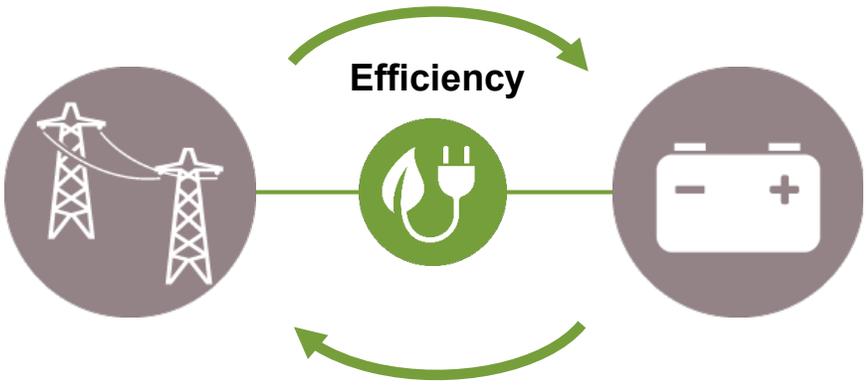
Efficiency

Realizing efficiency from grid to battery

Part of your life. Part of tomorrow.