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Power Surfing

MasterGaN rides the new wave of GaN Power

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Agenda

1. Energy management trends -> GaN vs. Silicon based transistors
2. Smart GaN: integrating GaN with driver
3. The MasterGaN* platform
4. The MasterGaN Ecosystems
5. Takeaways

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Energy management trends
GaN vs. Silicon based transistors

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The future of energy
Efficiency & power density


AC-DC adapters, USB-PD


Fast and wireless charging


Power for PC, OLED TV


Telecom / Server power


Power supply for 5G


Communication Infrastructure

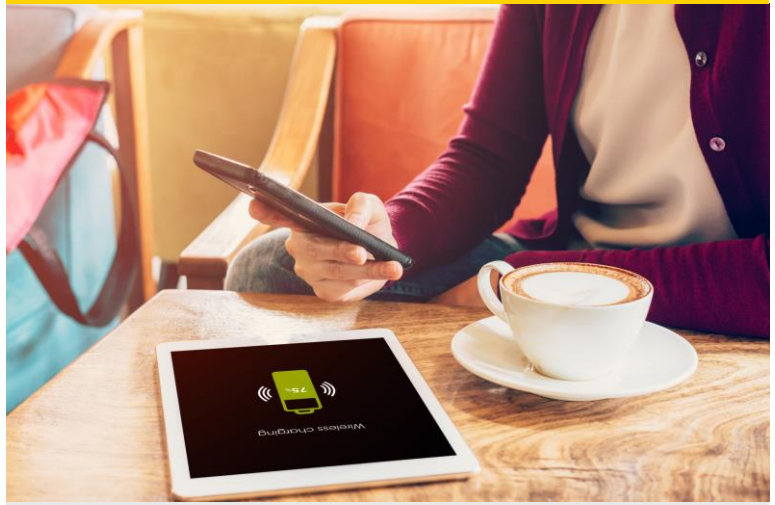

Energy storage systems (UPS)


Solar DC-AC converters


HV / HEV charging stations

High power – Mini size

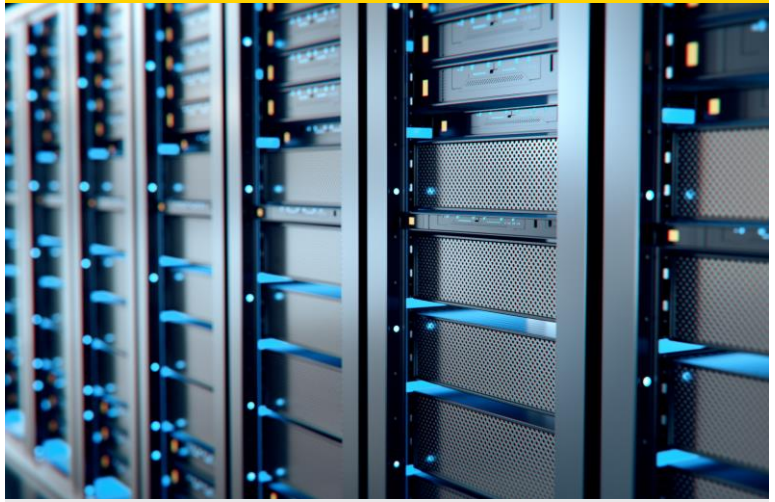
AC-DC adapter & Smartphone fast charger



4x smaller

3x lighter

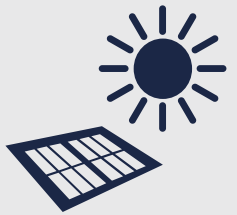
Server power supply



50% higher power density

20% lower P_{LOSS}

Solar ESS (Energy Storage System)



2x smaller

3x lighter

Fan-less

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Travel adapter development

Power Level Increasing 5W → 65W → 120W

Power Density Increasing 5W/in3 → 20W/in3 → 30W/in3

Switching frequency Increasing 60kHz → 150kHz → 350kHz

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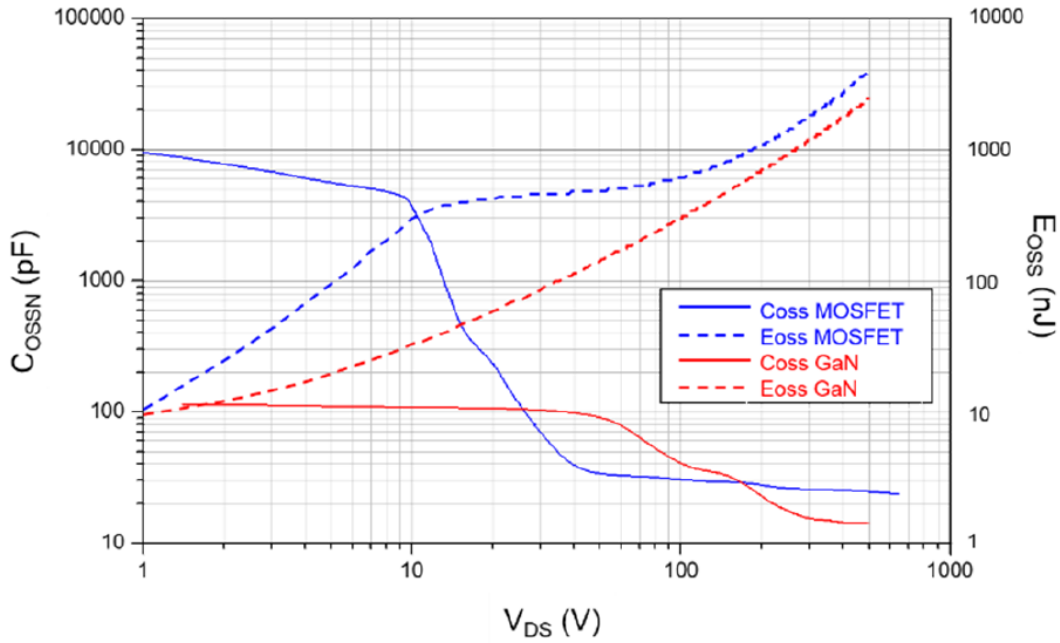
GaN vs. Silicon based transistors

GaN transistors allow higher frequencies, better efficiency and higher power density than silicon-based transistors

Parameter	GaN	Silicon	Comments
Qg-Gate charge	**Lower**	Higher	GaN has lower driver loss for higher frequency & efficiency
Coss-Output capacitance	**Lower**	Higher	GaN has lower switching loss for higher frequency & efficiency
Qrr-Reverse recovery charge	**Lower**	Higher	GaN suitable for higher frequency & efficiency
Vgs- gate voltage	Difficult	**Easy**	GaN needs better gate drive circuit and PCB layout
Vsd-body diode conduction	Higher	**Lower**	GaN needs better control of deadtime



C_{OSS} and Eoss comparison: 650V Si Mosfet with R_{DSon} = 270 $m\Omega$ vs. 650V GaN Transistor with R_{DSon} = 260 $m\Omega$

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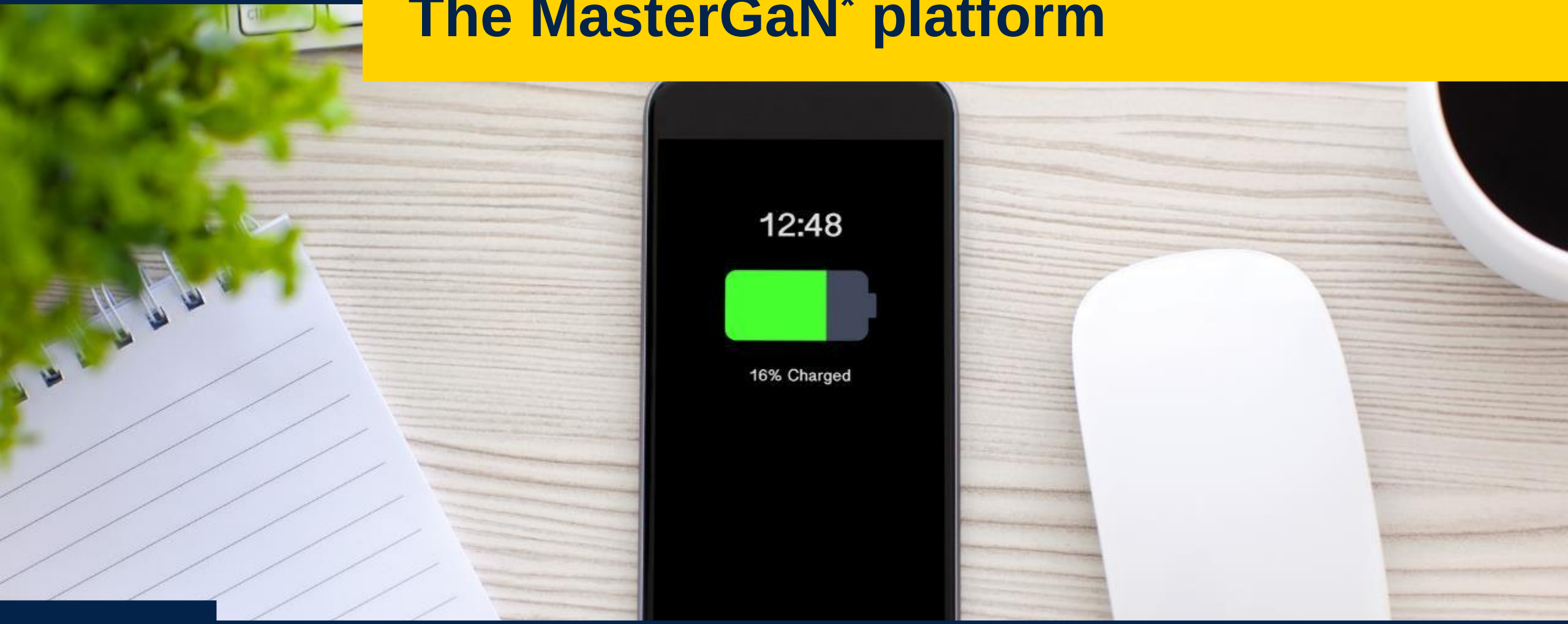
Smart GaN: integrating GaN with driver
The MasterGaN* platform



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Smart GaN: Integrating GaN with driver

Higher efficiency

Reduced power losses, reduced power consumption, exceeding the most stringent energy requirements

Higher power density

Higher switching speed to reduce systems size and cost

Faster go-to-market

Packaged solution simplifies the design, with a higher level of performance

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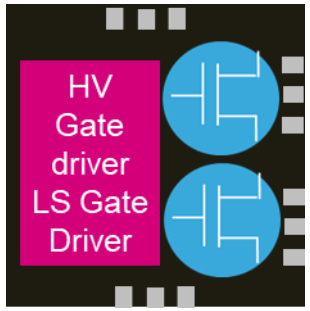
MasterGaN applications and benefits

	Applications
	Telecom/Server Power
	Power Supply for 5G Communication Infrastructure
	HV/HEV Charging Stations
	Energy Storage Systems (UPS)
	Solar DC-AC Converters
	PC Power, OLED TV
	High-Density AC-DC Adapters, Fast Charging, USB-PD



Key benefits

- Compact system solution and simplified layout
- BOM reduction:SiP with offline driver optimized for GaN
- Robust solution: driver and GaN power transistors integration
- Package GQFN 9x9
- Flexible, easy and fast design
- Scalable p2p solution for power range 30-400 W

MasterGaN
First in the market

Advanced power solution integrating a gate driver and two enhancement mode GaN transistors in half-bridge configuration

Mass production

MASTERGAN1

VDS	**600 V**
RDS_{ON}	**150 mΩ**
IDS_{MAX}	**10 A**

MASTERGAN2

VDS	**600 V**
RDS_{ON}	**150 mΩ (LS) + 225 mΩ (HS)**
IDS_{MAX}	**10 A (LS) + 6.5 A (HS)**

Compact

- Integrated power GaN
- Embedded gate driver easily supplied by the integrated bootstrap diode

Robust

- UVLO protection on both the lower and upper driving sections, preventing the power switches from operating in low efficiency or dangerous conditions, and the interlocking function avoids cross-conduction conditions
- Over temperature protection

Easy Design

- Smart solution in GQFN 9x9 mm^2 package
- Input pins extended range -3.3 to 15 V with hysteresis and pull-down- allows easy interfacing with microcontrollers, DSP units or Hall effect sensors
- Dedicated pin for shutdown functionality
- Accurate internal timing match

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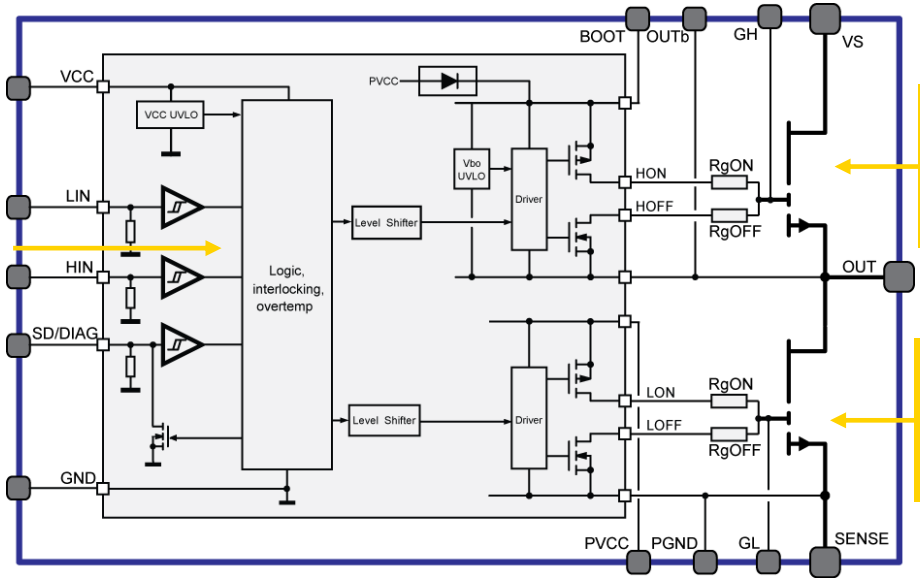
MasterGaN block diagram & Key features

High power density half-bridge 650V GaN with embedded driver

Driver



High-Side GAN transistor

Low-Side GAN transistor

GQFN 9x9

Features

- Power system-in-package integrating half-bridge gate driver and high-voltage GaN transistors:
  - BVDSS = 650 V
  - RDS(ON) = 150 mΩ
  - IDS(MAX) = 10 A
- Reverse current capability
- Zero reverse recovery loss
- UVLO protection on low-side and high-side
- Internal bootstrap diode
- Interlocking function
- Dedicated pin for shutdown functionality
- Accurate internal timing match
- 3.3 V to 15 V compatible inputs with hysteresis and pull-down
- Overtemperature protection
- Bill of material reduction
- Very compact and simplified layout
- Flexible, easy and fast design

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MasterGaN Gate drive logic inputs

Gate drive logic inputs truth table

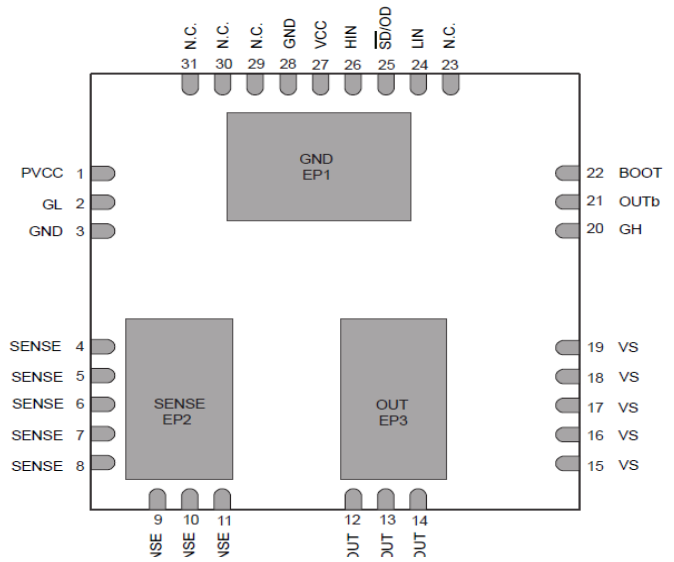
	Input pins			GaN transistors status	
	$\overline{SD}$/OD	LIN	HIN	LS	HS
Disabled input port	L	X	X	OFF	OFF
	H	L	L	OFF	OFF
Normal Operation Configurations	H	L	H	OFF	**ON**
	H	H	L	**ON**	OFF
Interlocking	H	H	H	OFF	OFF

1. X: Don't care

MasterGaN pinout

MasterGaN pinout

Figure 2. **Pin connection (top view)**



QFN 9x9

Pin Number	Pin Name	Type	Function
15, 16, 17, 18, 19	VS	Power Supply	High voltage supply (high-side GaN Drain)
12, 13, 14, EP3	OUT	Power Output	Half-bridge output
4, 5, 6, 7, 8, 9, 10, 11, EP2	SENSE	Power Supply	Half-bridge sense (low-side GaN Source)
22	BOOT	Power Supply	Gate driver high-side supply voltage
21	OUTb	Power Supply	Gate driver high-side reference voltage, used only for Bootstrap capacitor connection. Internally connected to OUT.
27	VCC	Power Supply	Logic supply voltage
1	PVCC	Power Supply	Gate driver low-side supply voltage
28, EP1	GND	Power Supply	Logic ground
3	PGND	Power Supply	Gate driver low-side driver reference. Internally connected to SENSE.
26	HIN	Logic Input	High-Side driver logic input
24	LIN	Logic Input	Low-Side driver logic input
25	$\overline{SD}$/OD	Logic Input-Output	Driver Shutdown input and Over-Temperature
2	GL	Output	Low-Side GaN gate.
20	GH	Output	High-Side GaN gate.
23, 29, 30, 31	N.C.	Not Connected	Leave floating

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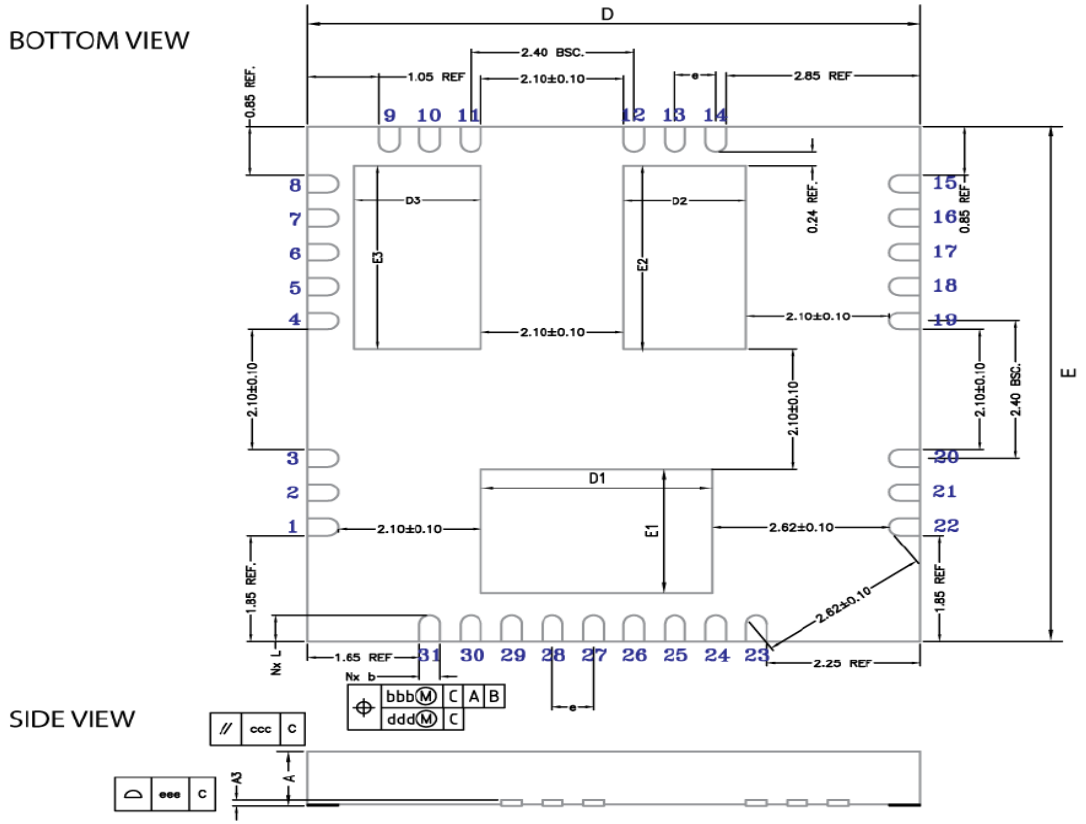
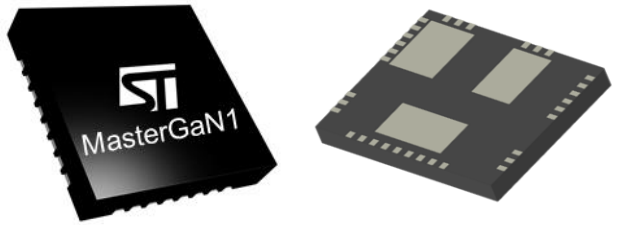
MasterGaN Footprint

Footprint with >2 mm creepage between HV and LV pads



Key features

- **Creepage distance >2 mm** between HV and LV pads
- **3 exposed pads for thermal dissipation**



GQFN 9x9

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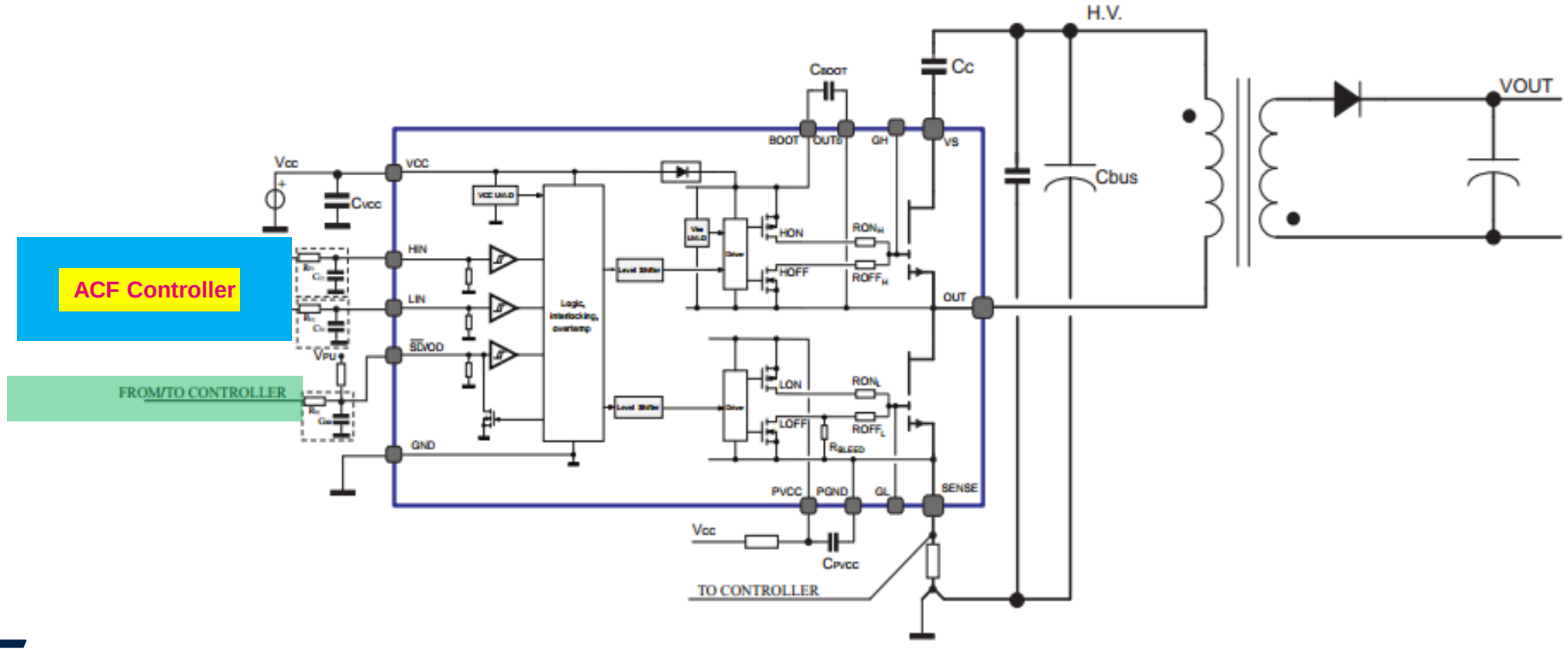
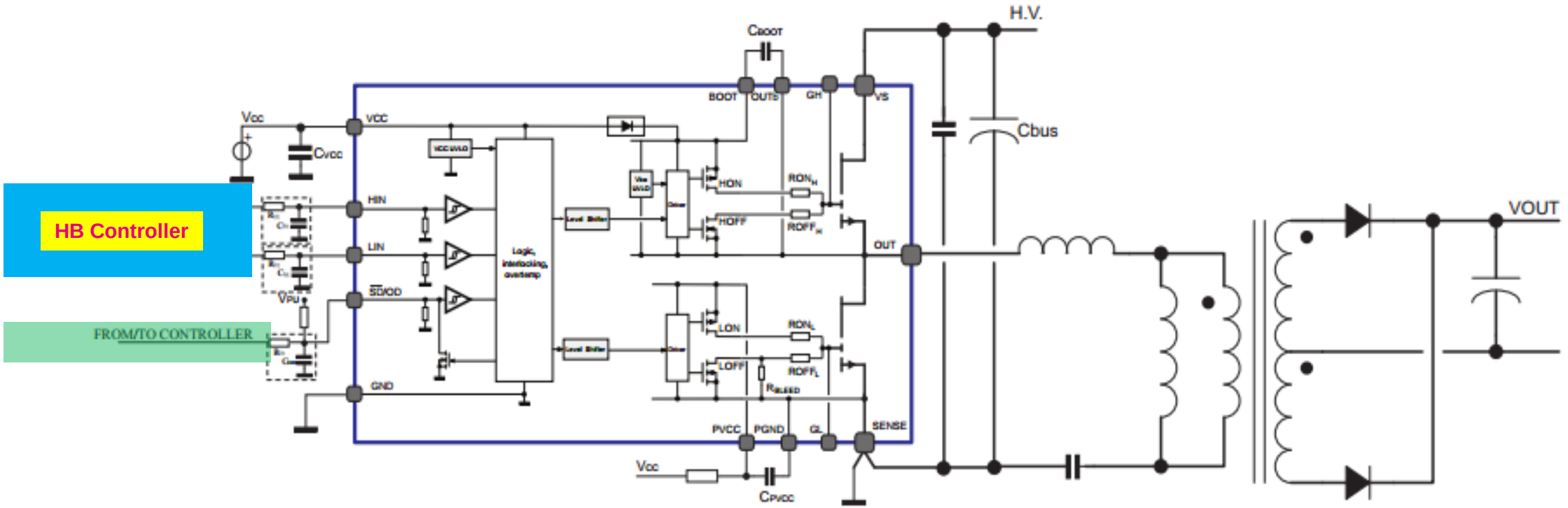
Typical application diagram

Active clamp flyback Topology



Typical application diagram

LLC Resonant Topology



The MasterGaN Ecosystems

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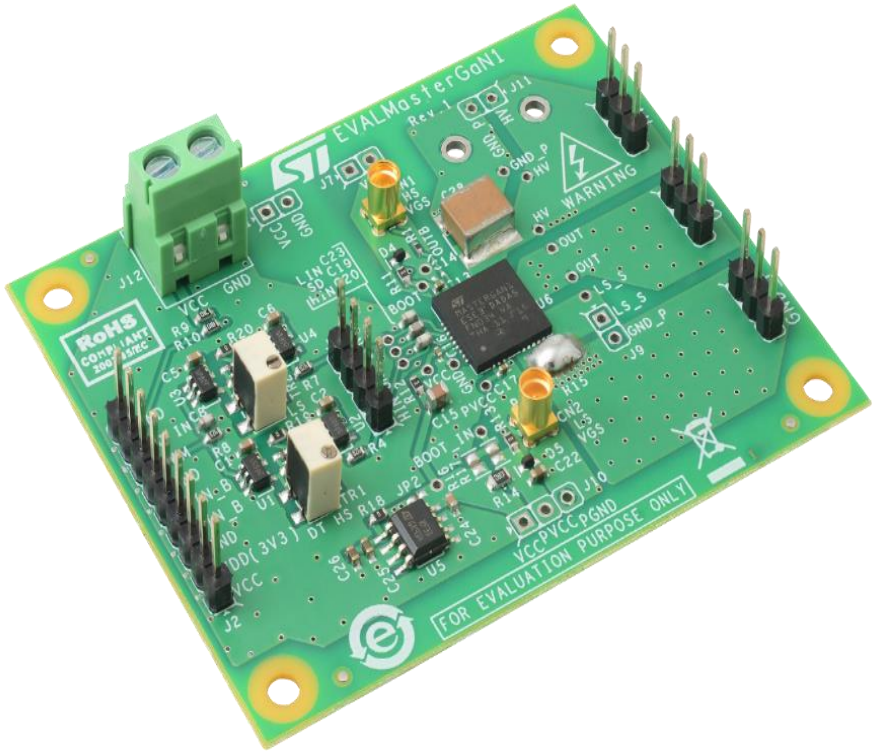
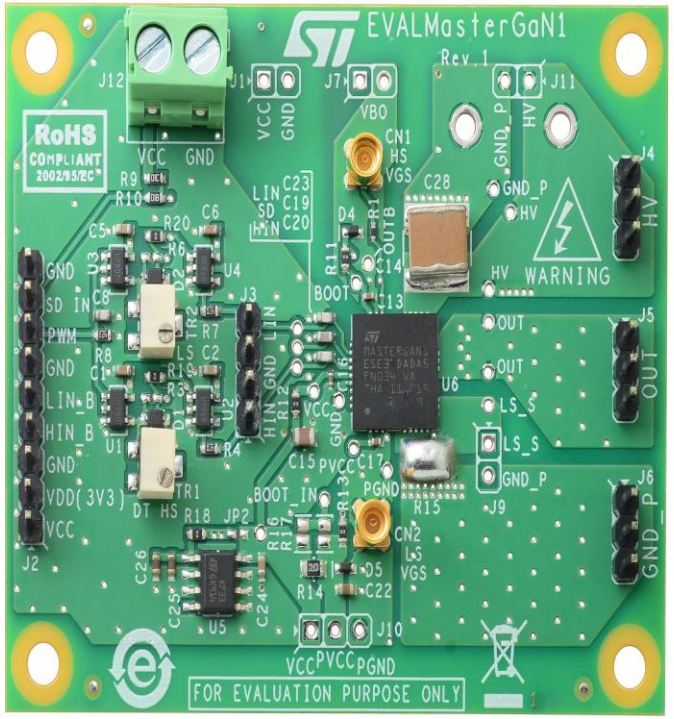
MasterGaN1 - Ecosystem

Evaluation board & ecosystem available at www.st.com/mastergan

Key applications

- Switch-mode power supplies
- Chargers and adapters
- High-voltage PFC
- DC-DC and DC-AC converters
- UPS systems
- Solar power





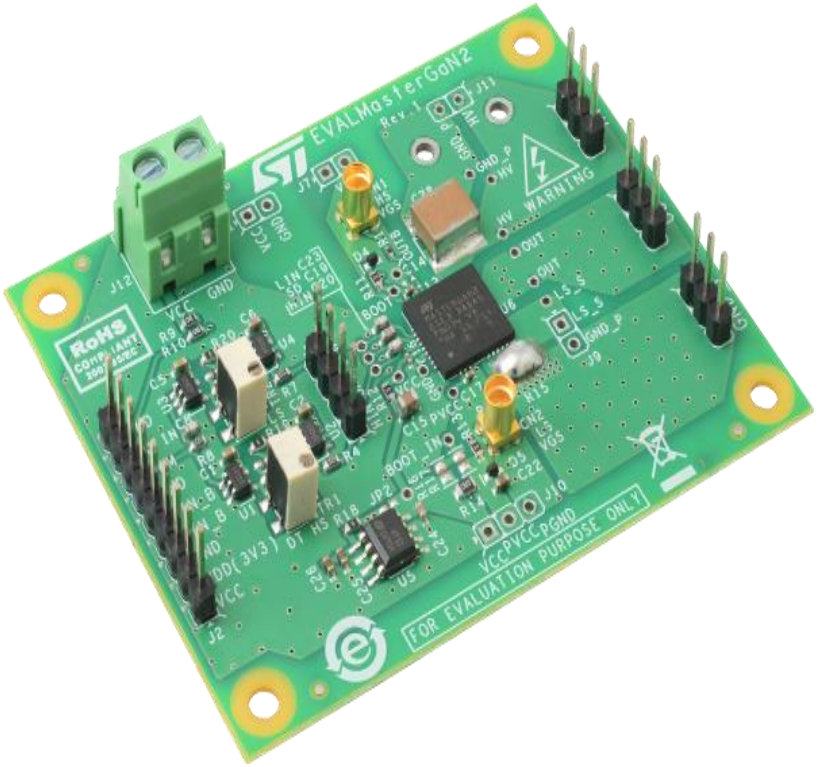
EVALMASTERGAN1

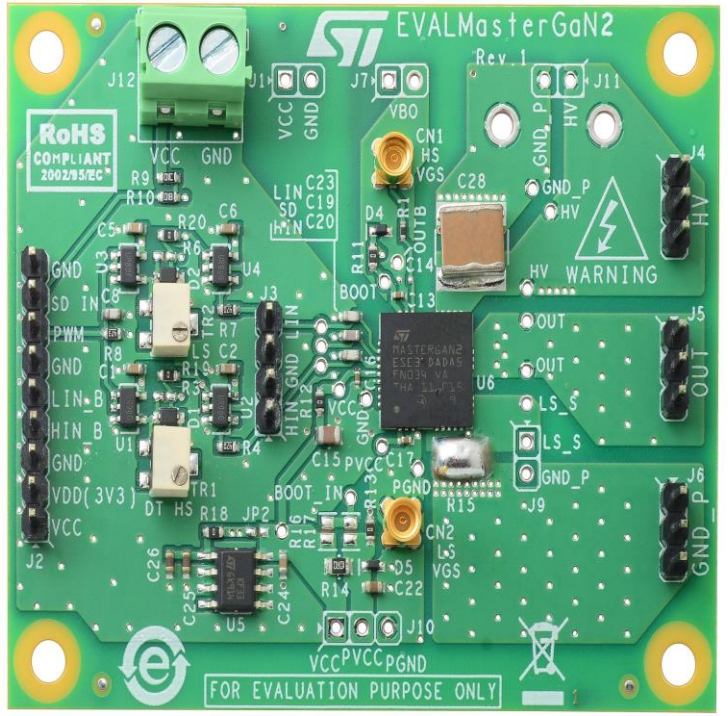
MasterGaN2 - Ecosystem

Evaluation board & ecosystem available at www.st.com/mastergan

Key applications

- Switch-mode power supplies
- Chargers and adapters
- High-voltage PFC
- DC-DC converters





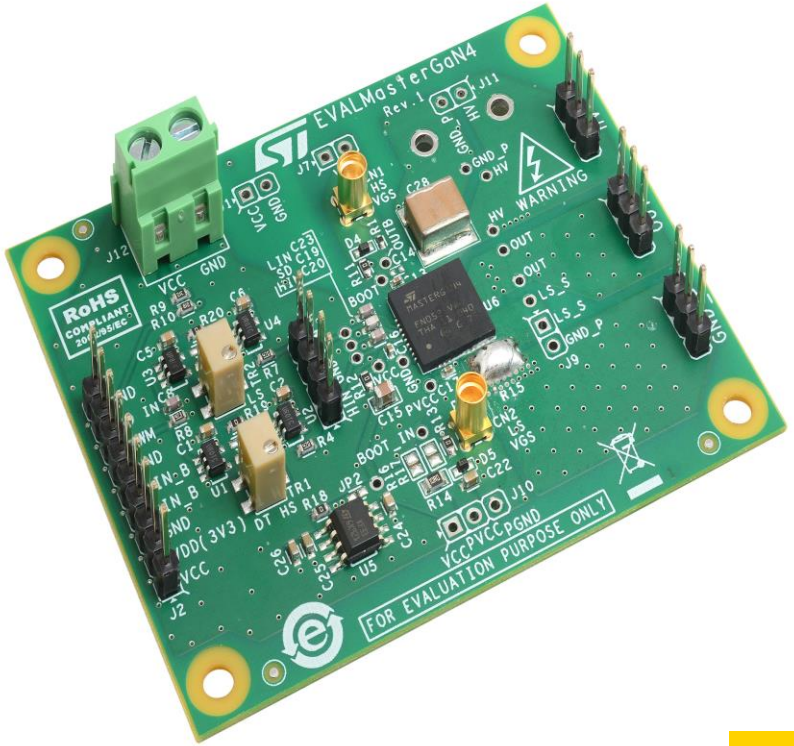
EVALMASTERGAN2

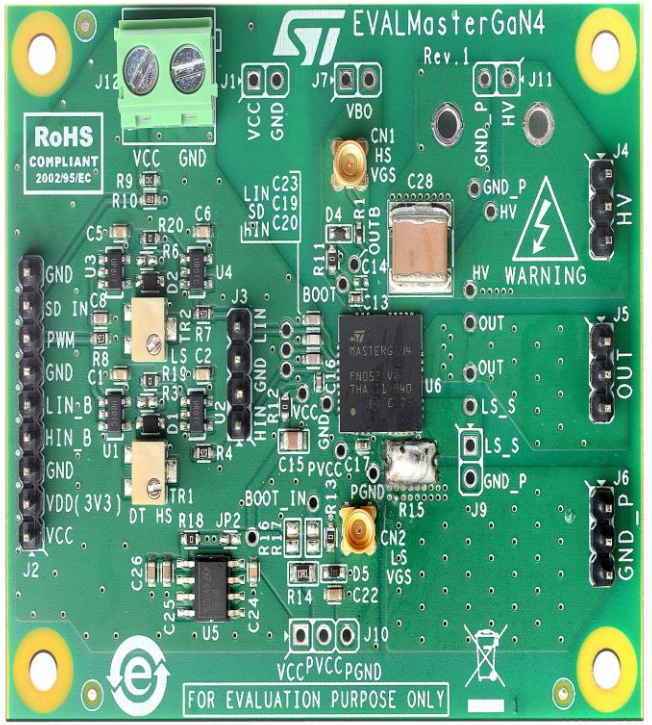
MasterGaN4 - Ecosystem

Evaluation board & ecosystem available at www.st.com/mastergan

Key applications

- Switch-mode power supplies
- Chargers and adapters
- High-voltage PFC
- DC-DC converters
- DC-AC converters





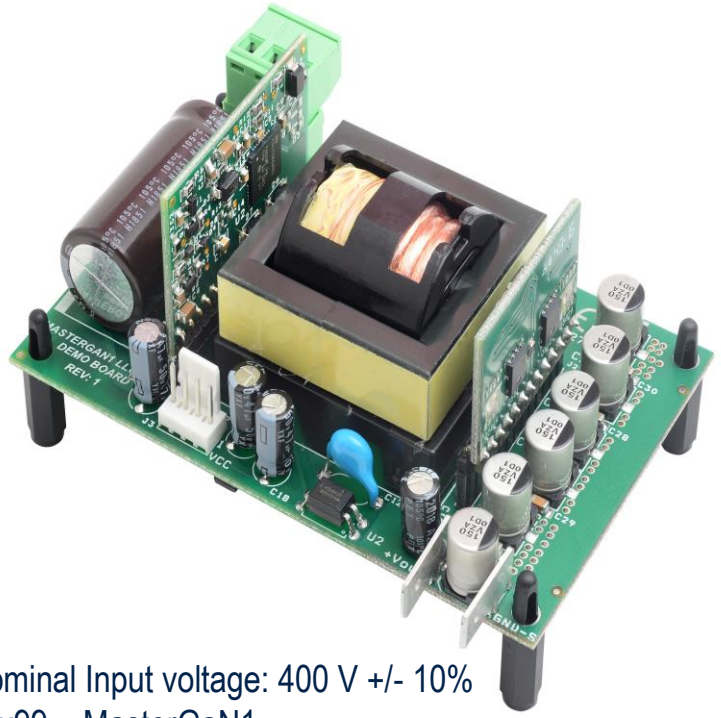
EVALMASTERGAN4

MasterGaN1 – 250W Resonant Ecosystem

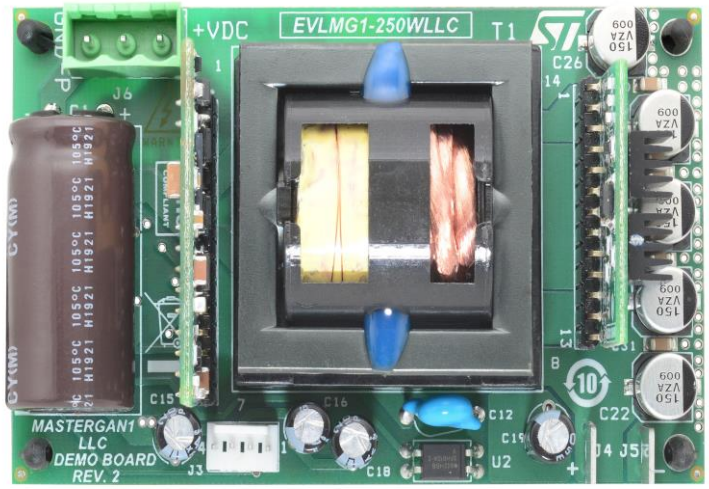
Evaluation board & ecosystem available at www.st.com/mastergan

Key applications

- Switch-mode power supplies
- Chargers and adapters
- Industrial DC-DC applications
- Consumer SMPS



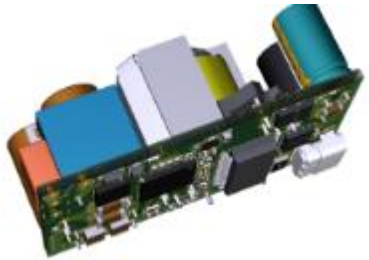
Nominal Input voltage: 400 V +/- 10%
L6x99 + MasterGaN1
Vout=24V
100 x 60 x 35 (W x H) mm.



EVLMG1-250WLLC

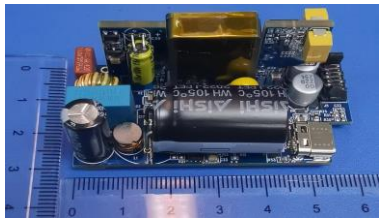
MasterGaN solutions under development

MasterGaN solutions to address a variety of application



AVAILABLE FOR SELECTED CUSTOMERS

65W STOne Compact Board
STOne + MasterGaN1 USB-PD
RM8 Transformer
Power density: 30W/in^3 (uncased)



UNDER DEVELOPMENT (Q2'21)

65W STOne Planar Compact Board
for TA charger
STOne + MasterGaN2 USB-PD
Planar Transformer

AVAILABLE FOR SELECTED CUSTOMERS

65W STOne Evaluation Board
STOne + MasterGaN1 USB-PD
RM8 Transformer
Customizable board to specific customer requirements

UNDER DEVELOPMENT (Q2'21)

200W TM PFC+LLC Board
Gaming NoteBook
STCMB1 + MasterGaN1

Takeaways

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MasterGaN family roadmap
QFN 9x9 mm² pin-to-pin scalable

One driver, many standard transistors for HB configuration

From 45 up to 400 W

MasterGaN1	MasterGaN2	MasterGaN3	MasterGaN4	MasterGaN5
Symmetrical	Asymmetrical	Asymmetrical	Symmetrical	Symmetrical
150 + 150 mΩ	150 + 225 mΩ	225 + 450 mΩ	225 + 225 mΩ	450 + 450 mΩ
Mass production	Mass production	Development	Mass production	Development

Whole product family to be released by H1 2021

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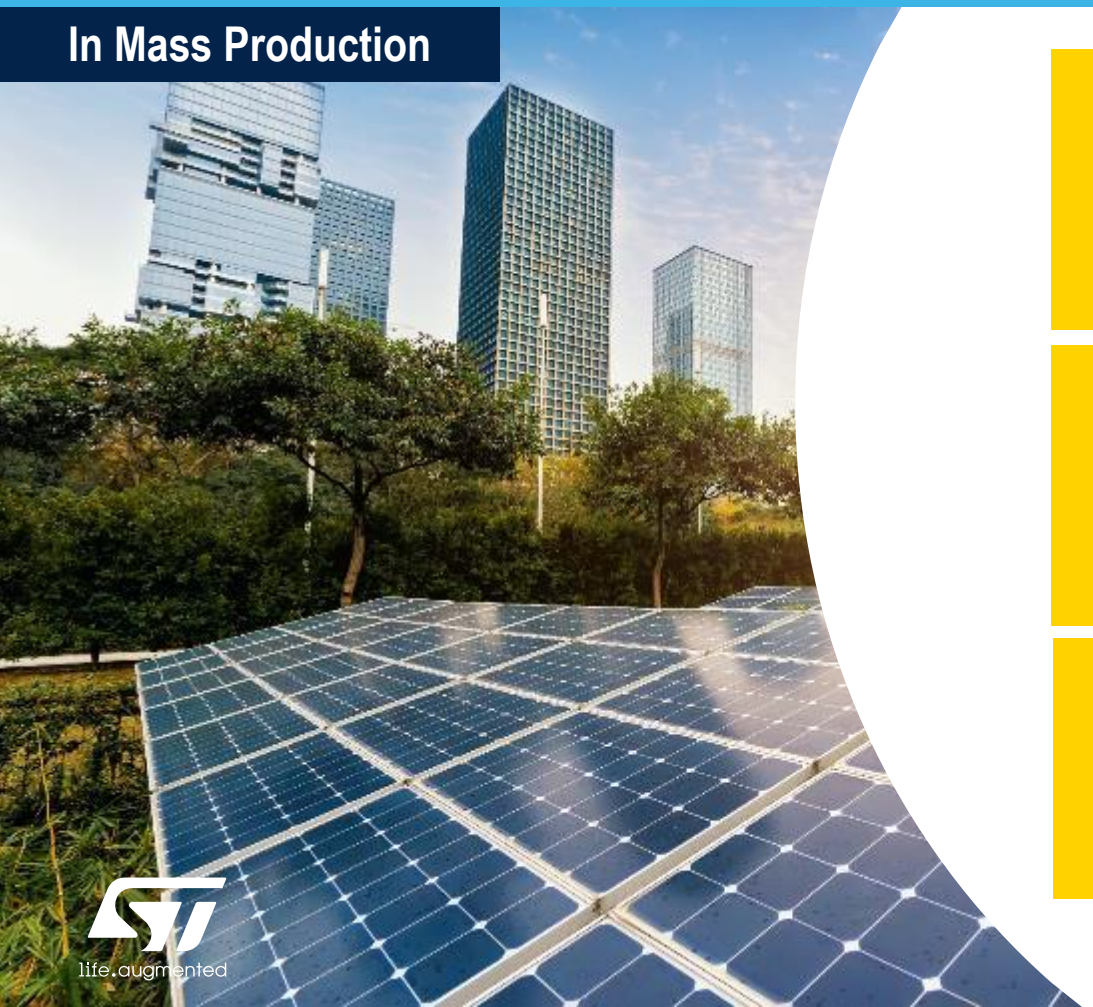
MasterGaN End applications

MasterGaN solutions to address a variety of application Switch-mode power supplies from 65 to 400 W in high-end, high-efficiency topologies

In Mass Production



Active Clamp Flyback/ Forward	65 W	Smartphone ultra-fast and wireless chargers, USB-PD compact adapters for pc and gaming
Totem-pole PFC, Resonant	100 W	Industrial power supplies like solar-energy storage systems, uninterruptible power supplies (UPS)
Totem-pole PFC, Resonant	400 W	High-end OLED TVs, server cloud

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MasterGaN rides the new wave of GaN Power

Increasing efficiency & power density is a clear trend

GaN HEMT make a quantum leap in power conversion

Smart GaN ICs maximize the benefits of the new technology

MasterGaN® takes the challenge first

Smart GaN innovation leverages ST leadership in power conversion

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