

# GaN Integrated Circuits for Highest Performance Power Supplies

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Innovative patented  
circuit architecture for  
AC/DC Power supply

Design expertise and  
improved GaN/Si  
Design Kit for GaN IC



National R&D center



GaNWise  
Fabless company

Offer to market

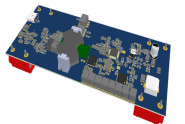
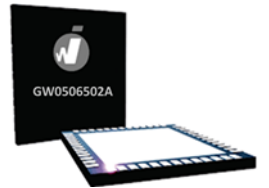
Gan-ICs

Power + driver

Mass production (TMSC)

Reference design

Application support



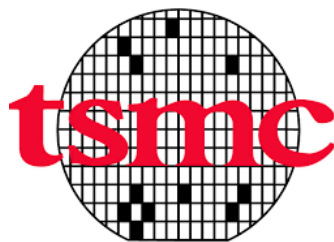


Innovation from national R&D center



life.augmented

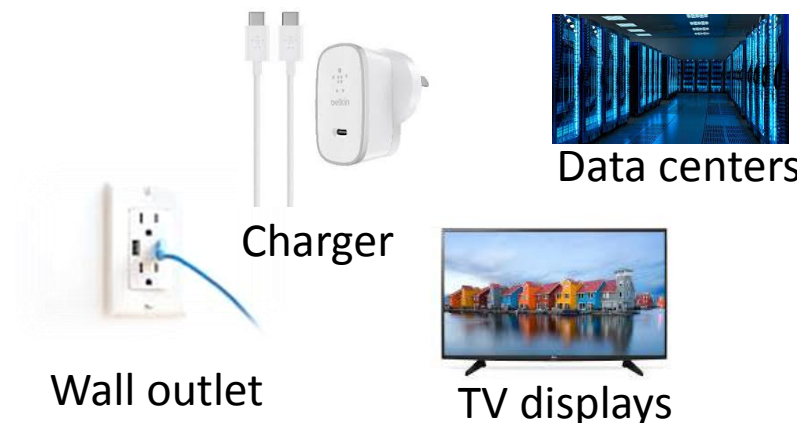
Industrial partner for applications



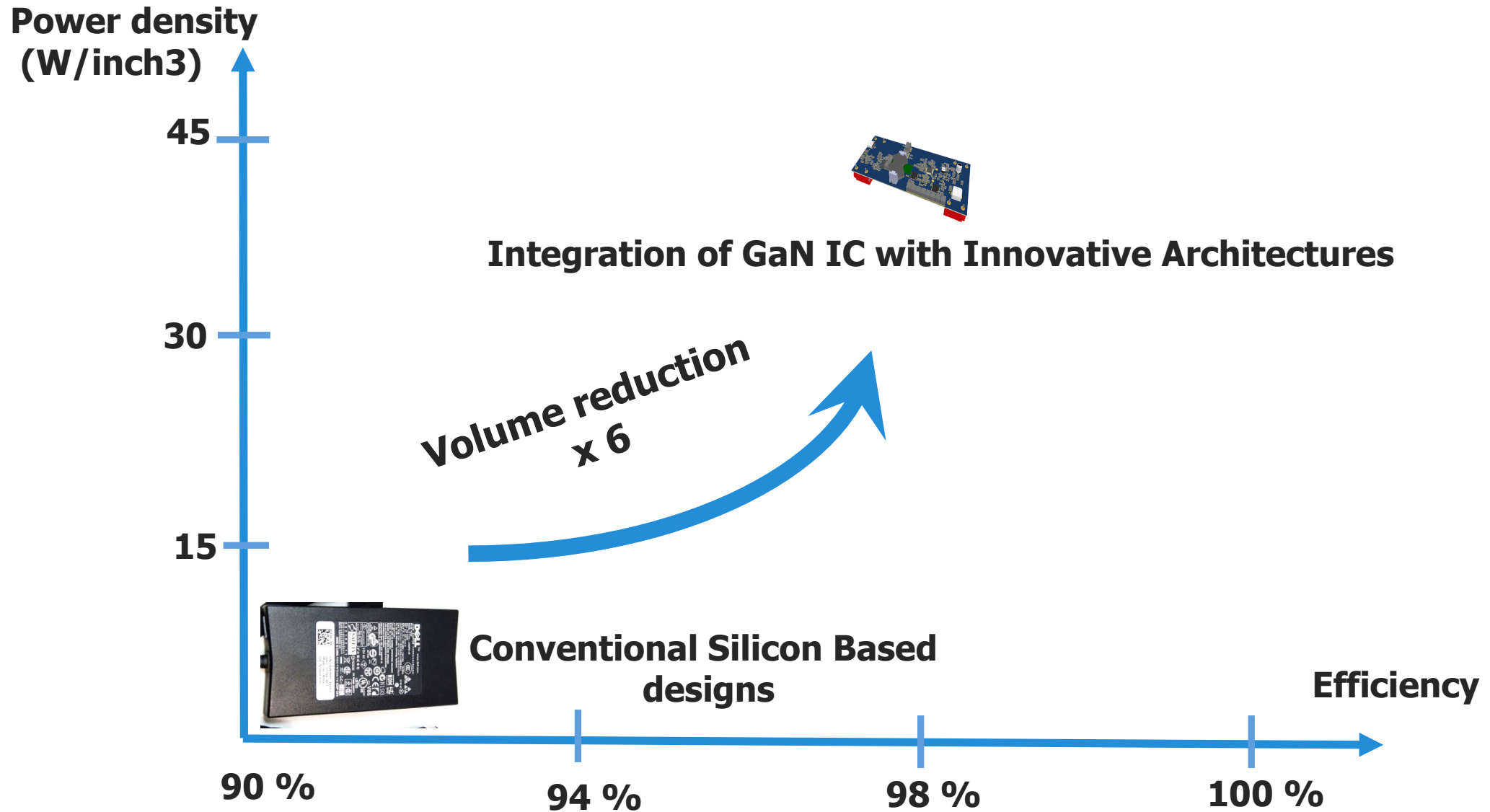
Industrial partner for manufacturing



GANWISE Fabless  
company



Wall outlet  
Battery Operated Consumer Electronics  
House Hold Power Supplies, Charger  
TV displays, datacenters



GaN for power conversion has now proved its ability to enable higher operating frequencies and higher efficiency, however...

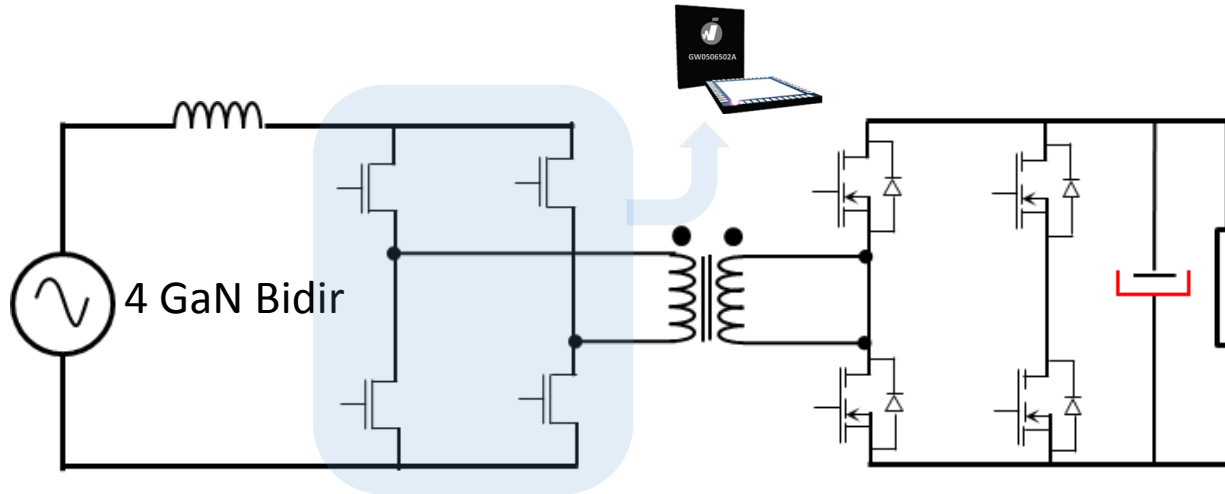
- High frequency means high speed commutations,
- High speed commutation (high  $dv/dt$  and  $di/dt$ ) produces unwanted perturbations due to *stray inductances* in the circuit,  $V=L di/dt$ . Stray inductances come from packaging and coppers tracks in PCB connecting various elements in the power signal path.

→ Integrating along the power path reduces stray inductance and allows fast and clean commutations.





→ GaN integration means getting the power transistors together with the gate drivers on the same die to start with.

- Innovative embedded Dual Active Bridge (e-DAB)

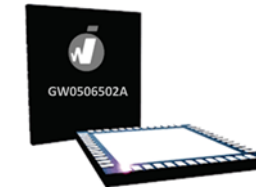
- 1 gate Bidirectional GaN transistors
- ZVS detection & control



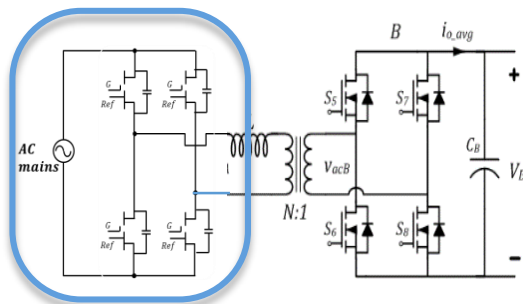
AC input bridge using AC switches  
Integrated in one die !

-  **Smaller** High power density & rectifier bridge removed with bidirectional devices
-  **Reliability** reduced high voltage component count
-  **More efficient** = low losses with ZVS in the DAB architecture
-  **Cost effective**= TSMC GAN/Si CMOS compatible technology high volume capability

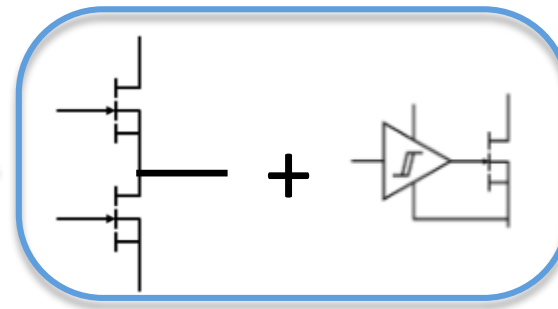
- Monolithic Power GaN integrated circuit (Driver + Power in one die)
- Done with a patented innovative e-DAB architecture
- On a new GaN/Si qualified technology from TSMC



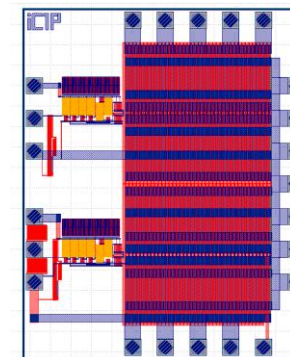
DAB architecture (AC-DC)



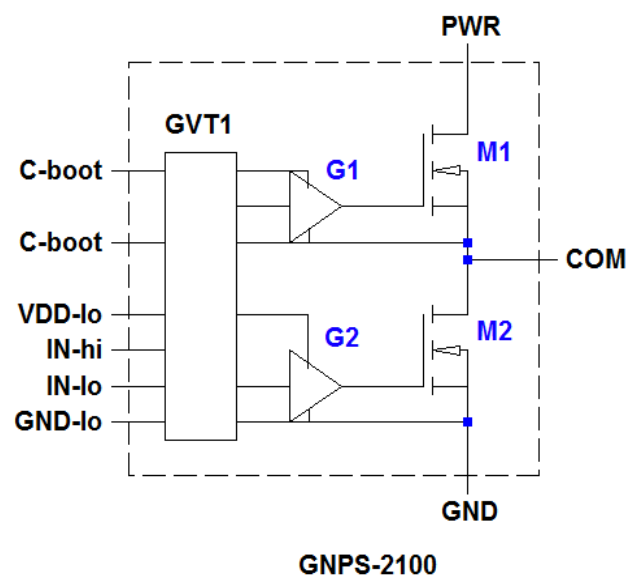
Power cell driver



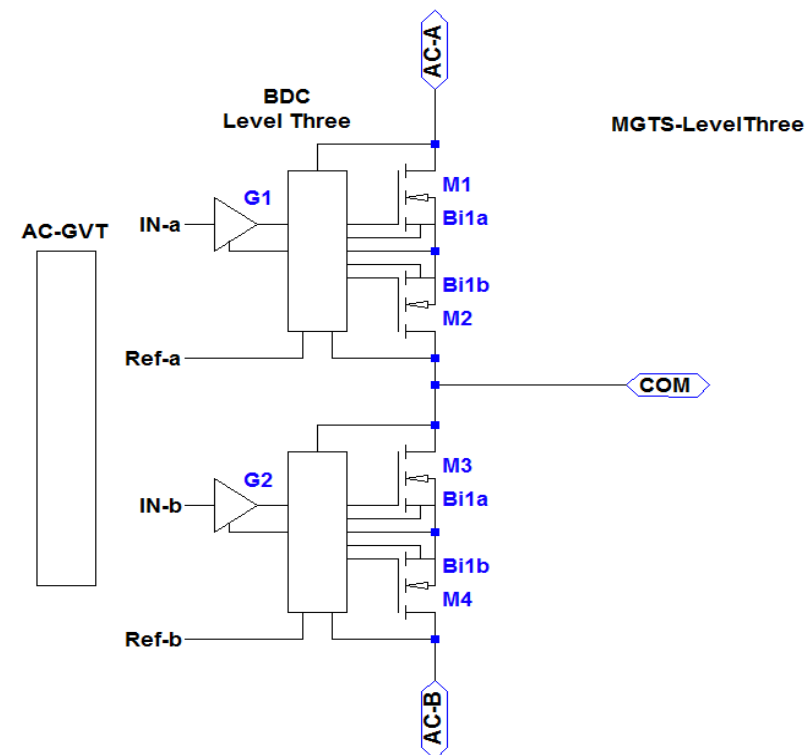
GaN Power IC



Half bridge + driver + level shifter

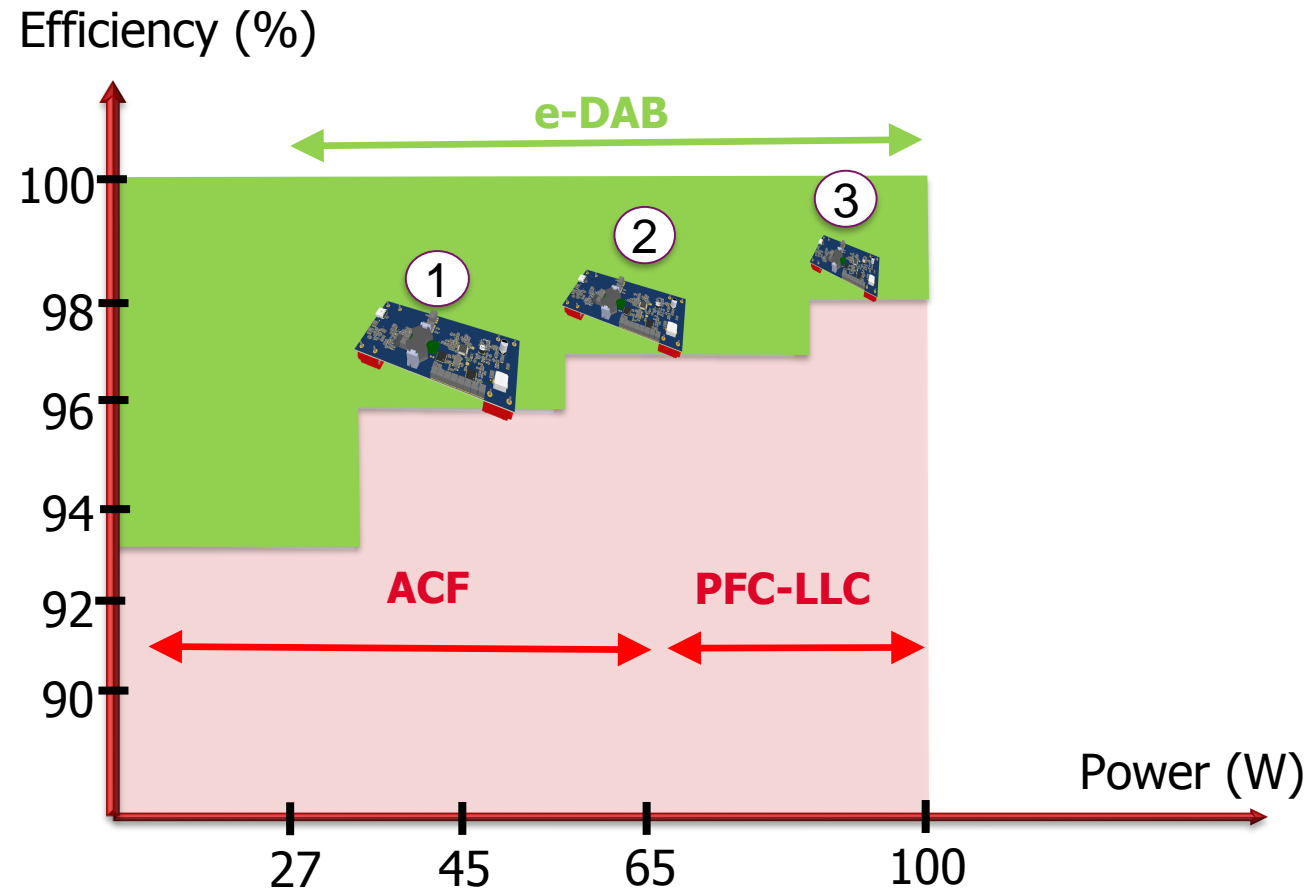


Half bidirectional bridge + driver  
+ level shifter

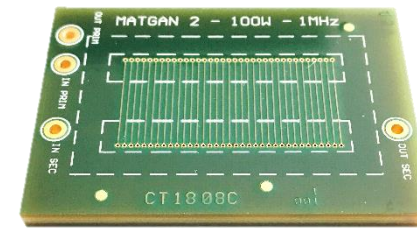
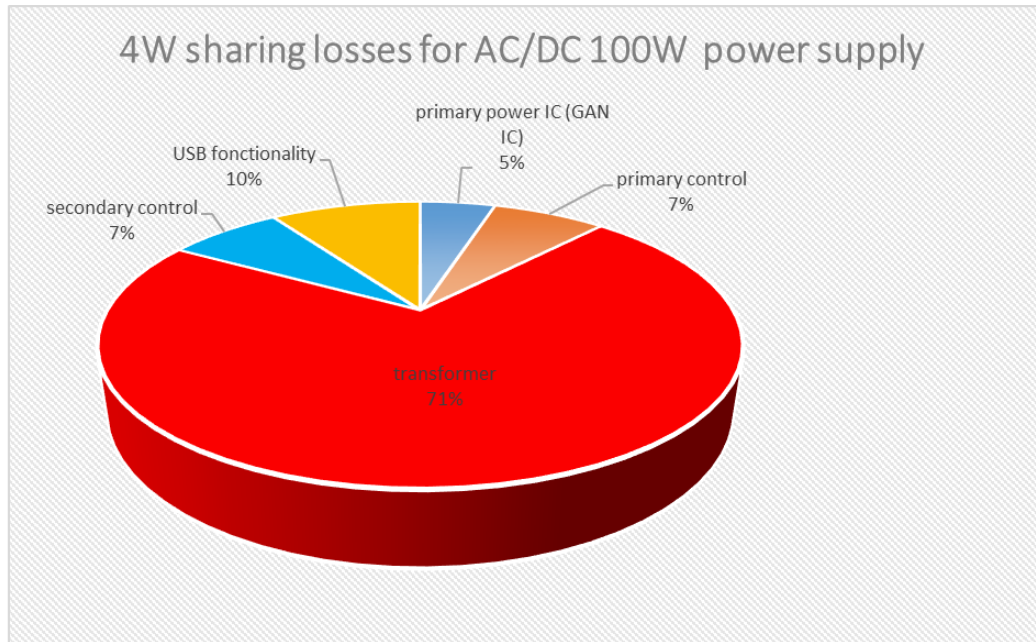




- Improve efficiency: 96% to 98%
- Reduce size: power density > 3kW/l
- Compatible for all power range : PFC integrated in the primary side



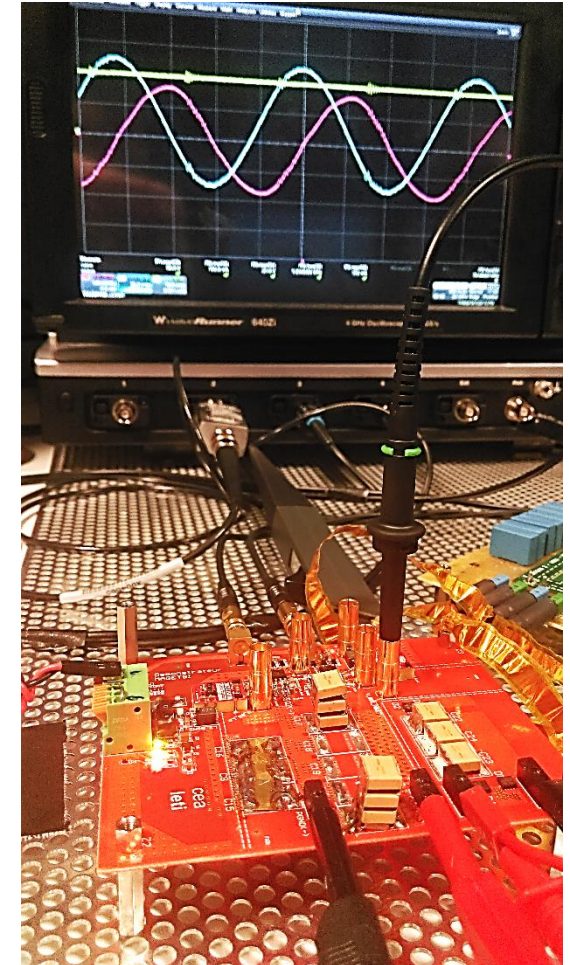
- Super Flat 1mm thick Magnetic Core integrated in PCB



**100W, 1MHz prototype  
integrated transformer  
using proprietary magnetic core  
(CEA-tech Liten)**

- + Smaller
- + More efficient

**100W, 1MHz AC-DC  
power supply tests  
240V AC → 20 VDC**



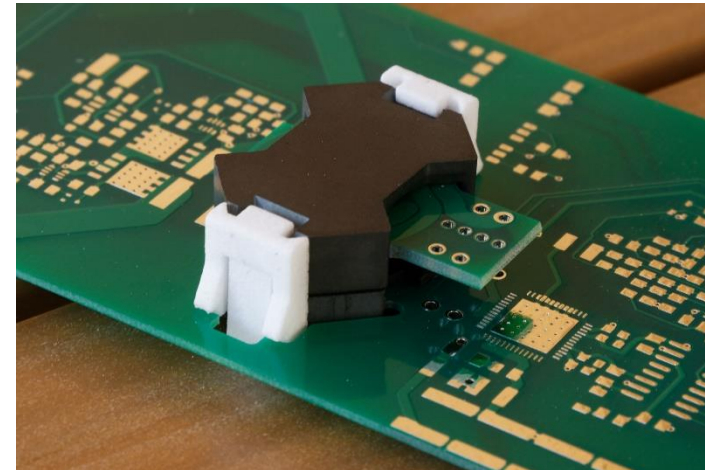
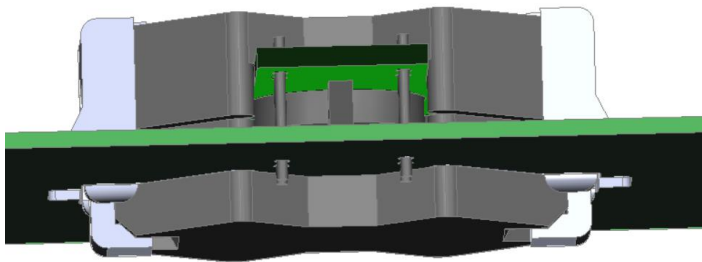
**Target** : high frequency planar compact transformer working at 1MHz with optimized yield upper 97%.

## Optimize Copper and Fe losses.

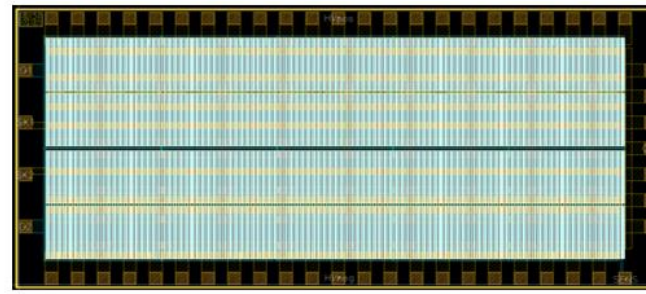
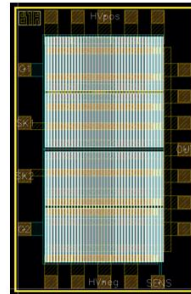
We use Ferroxcube material with 30mT and we have

- Fe losses: 1W
- Copper losses: 2W

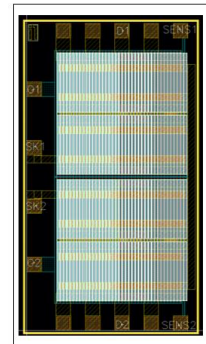
Transformer is included in the PCB board. Primary side is inside the PCB board.



Half bridge 100mR    Half bridge 20mR

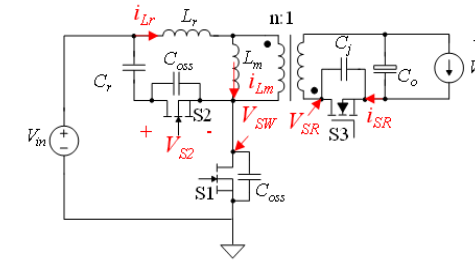
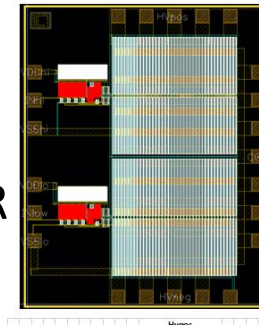


Scalable current capability

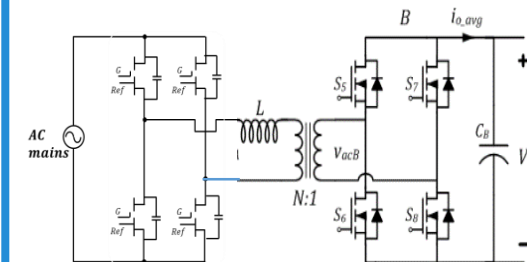


Half Bidirectional bridge 100mR

Half bridge 100mR  
+ Gate Drivers



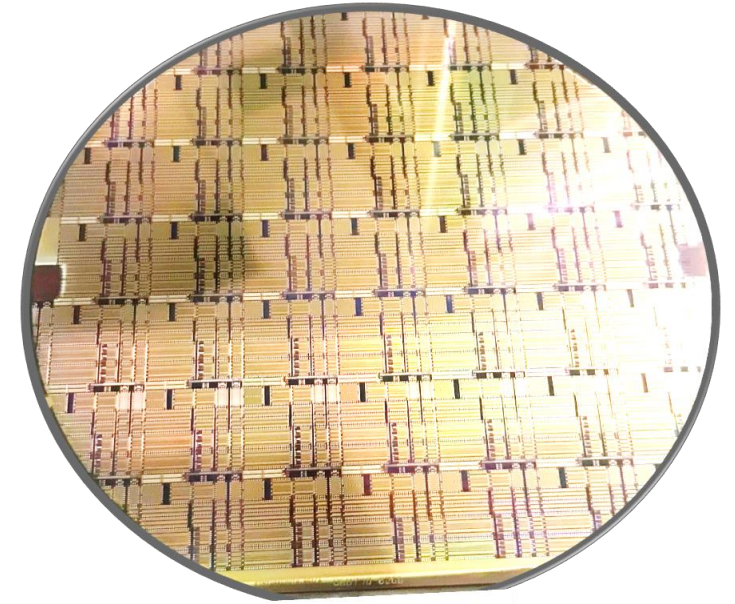
Active Clamp Flyback < 65W

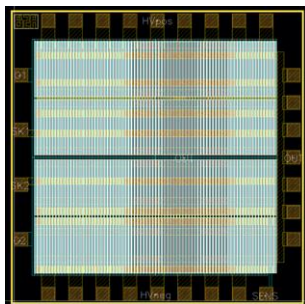


e-DAB > 65W

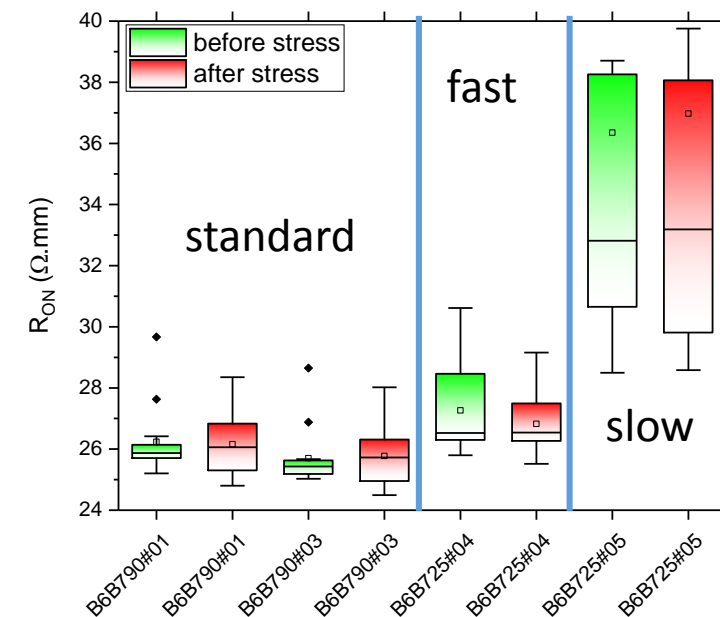
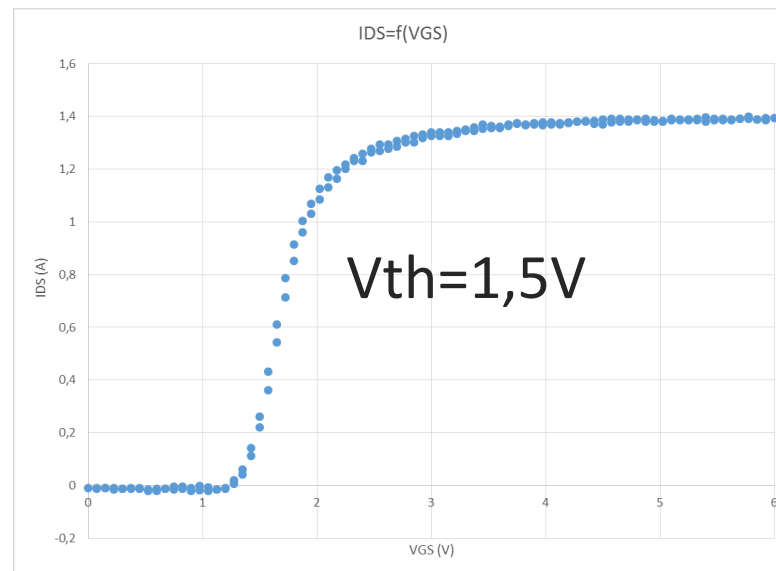
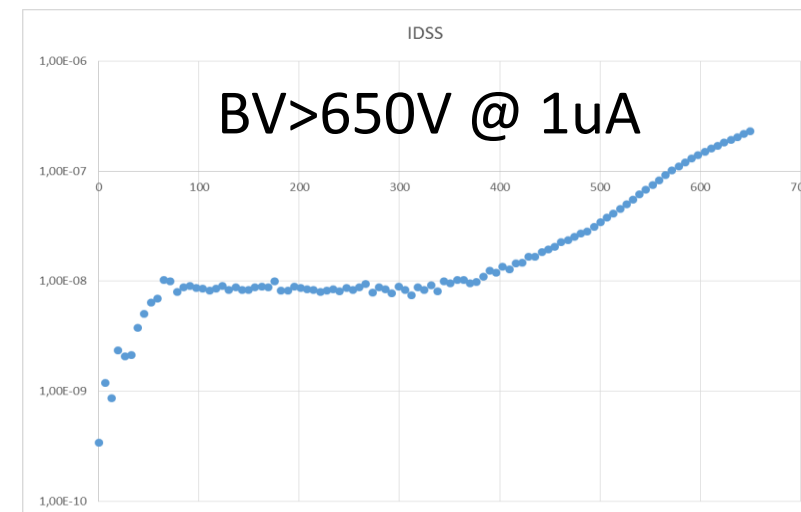
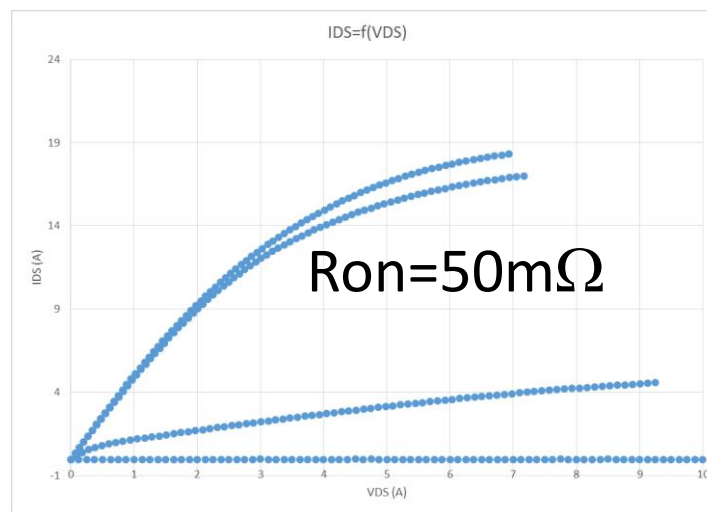


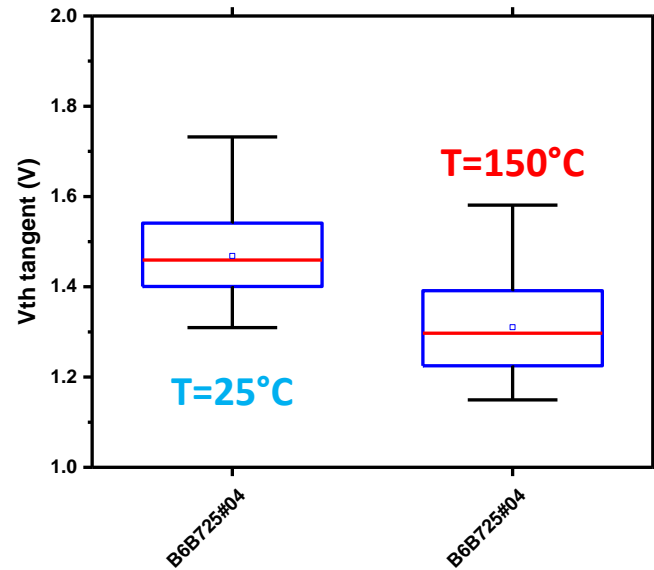
- Validation of static behavior of all devices in the first lot
- Discrete power transistor 650V/100mΩ /50mΩ and 20mΩ ( $R_{on.S}=4 \text{ m}\Omega.\text{cm}^2$ )
- With kelvin source and current sense pad
- Bidirectional power transistor 650V/40mΩ & 80mΩ
- Driver for half bridge 1MHz operation
- Level shifter for half bridge
- Pad ESD protection





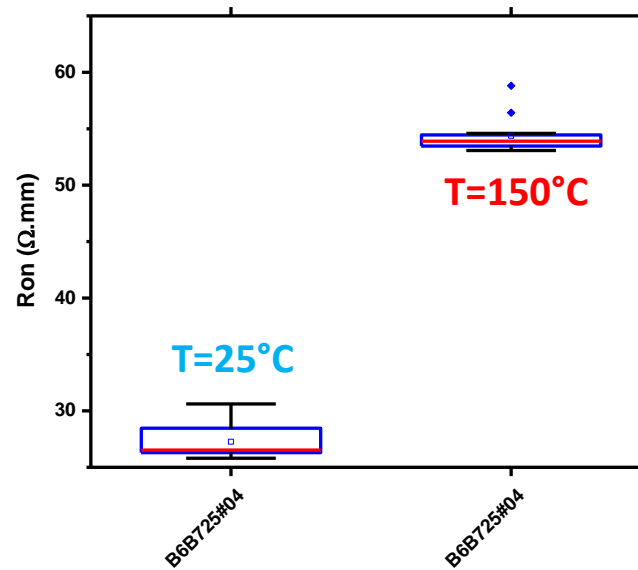
3 mm square





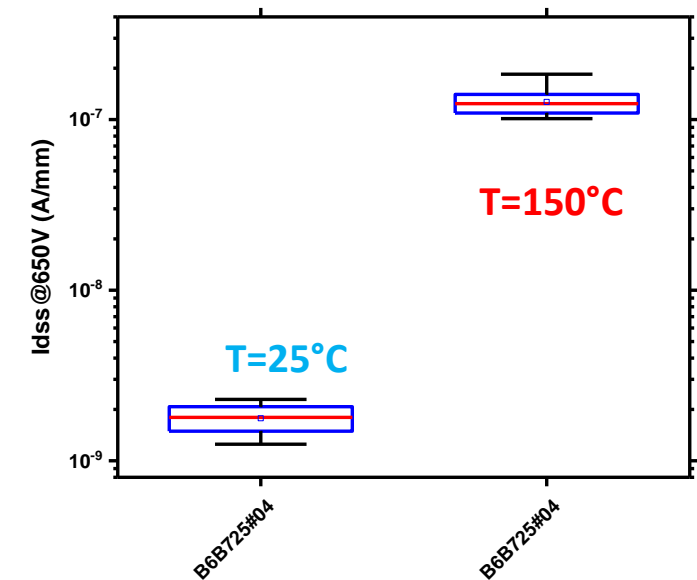
$V_{th}$  decreases with the temperature

- $V_{th}@25^{\circ}\text{C} = 1,5\text{V}$
- $V_{th}@150^{\circ}\text{C} = 1,3\text{V}$



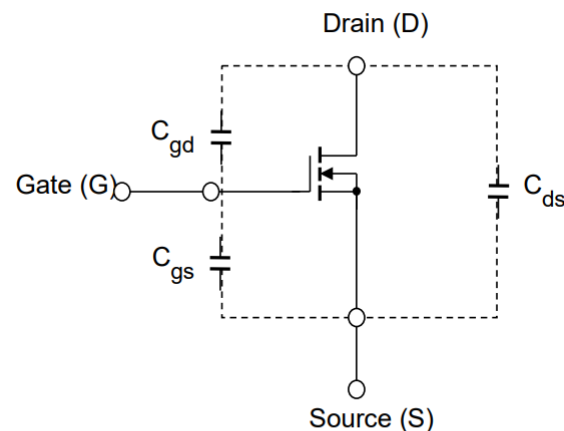
$R_{DS(ON)}$  increases with the temperature

- $R_{on}@25^{\circ}\text{C} = 26 \Omega\cdot\text{mm}$
- $R_{on}@150^{\circ}\text{C} = 53 \Omega\cdot\text{mm}$



$I_{dss}$  increase with the temperature

- $I_{dss}@25^{\circ}\text{C} = 1,9 \cdot 10^{-9} \text{ A/mm}$
- $I_{dss}@150^{\circ}\text{C} = 1,3 \cdot 10^{-7} \text{ A/mm}$

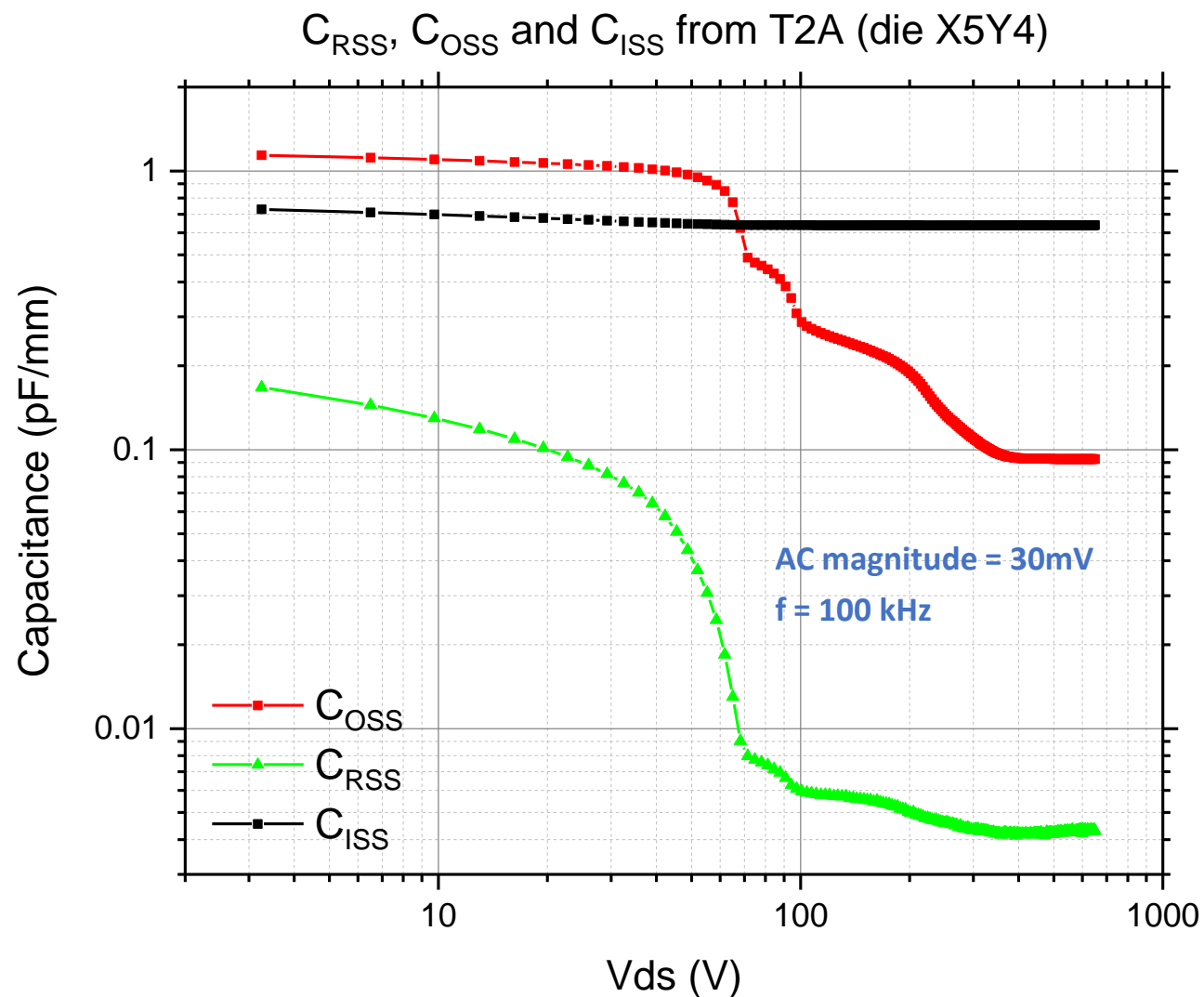


Input capacitance ( $C_{iss}$ ) =  $C_{gd} + C_{gs}$

Output capacitance ( $C_{oss}$ ) =  $C_{ds} + C_{gd}$

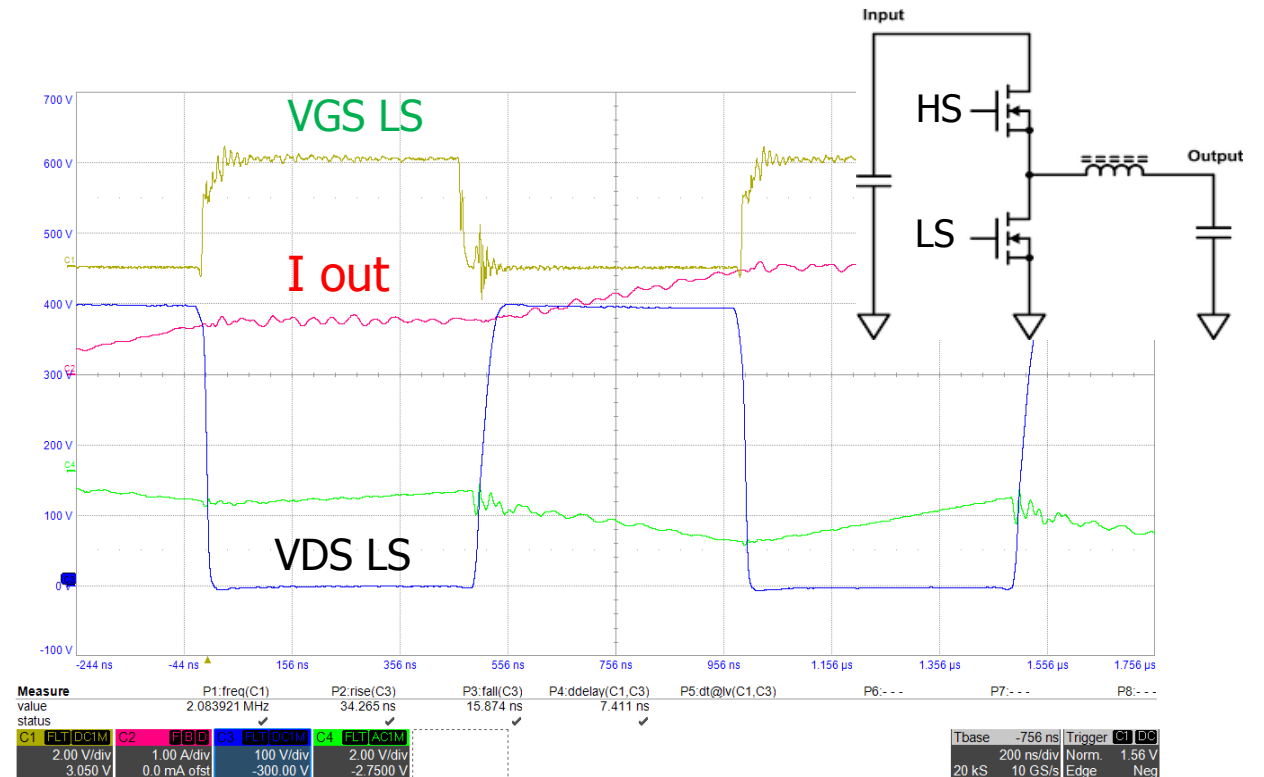
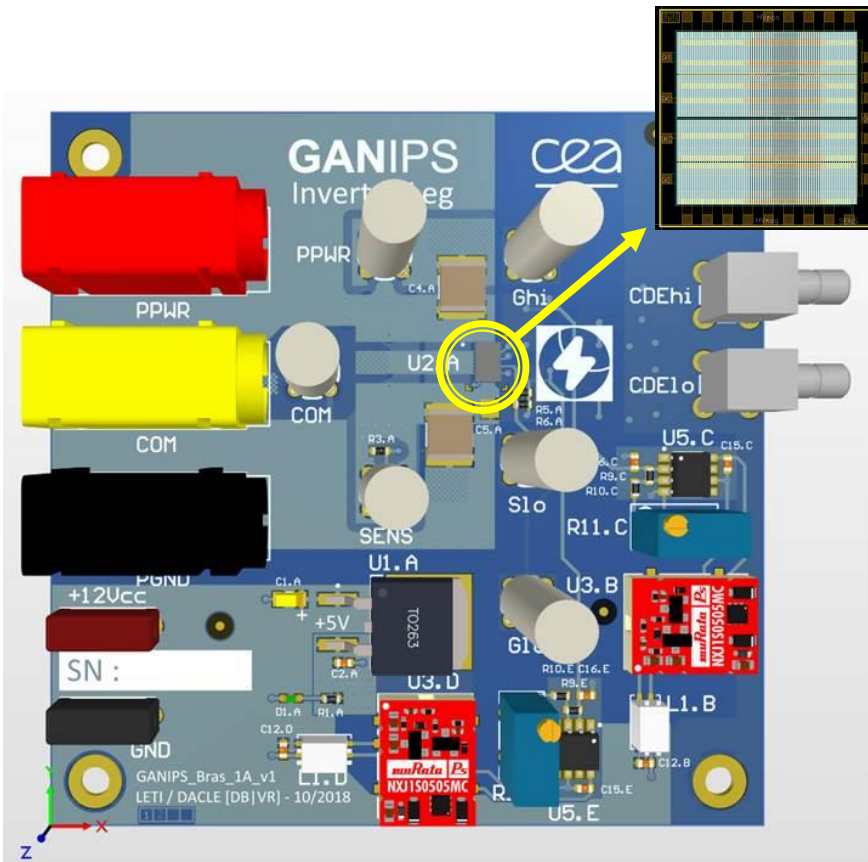
Reverse transfer capacitance ( $C_{rss}$ ) =  $C_{gd}$

Spec	T = 25°C
$C_{iss}$ (pF/mm)	0,64
$C_{oss}$ (pF/mm)	0,1
$C_{rss}$ (pF/mm)	$4 \cdot 10^{-3}$





- Integrated half bridge tested in buck mode 1MHz / 400V / 2A



- GaN IC assy in 8x8mm QFN package: half bridge with source sense and source kelvin
- Use for prototyping the 100W USB type C PD power supply



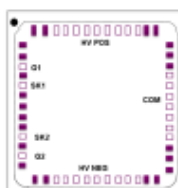
GW0506502A  
Half bridge Power GaN IC 650 V E-mode GaN transistor  
Preliminary Datasheet

## Features

- 650 V enhancement mode half bridge power switch
- Bottom-side cooled configuration
- $R_{DS(on)} = 50 \text{ m}\Omega$  per switch
- $I_{DS(max)} = 5 \text{ A}$
- Low inductance QFN PACKAGE
- Easy gate drive requirements (0 V to 6 V)
- Transient tolerant gate drive (-20 V / +10V)
- Very high switching frequency (> 10 MHz)
- Fast and controllable fall and rise times
- Integrated Source sense
- Reverse current capability
- Zero reverse recovery loss
- Small 8 x 8 mm<sup>2</sup> PCB footprint
- RoHS 6 compliant



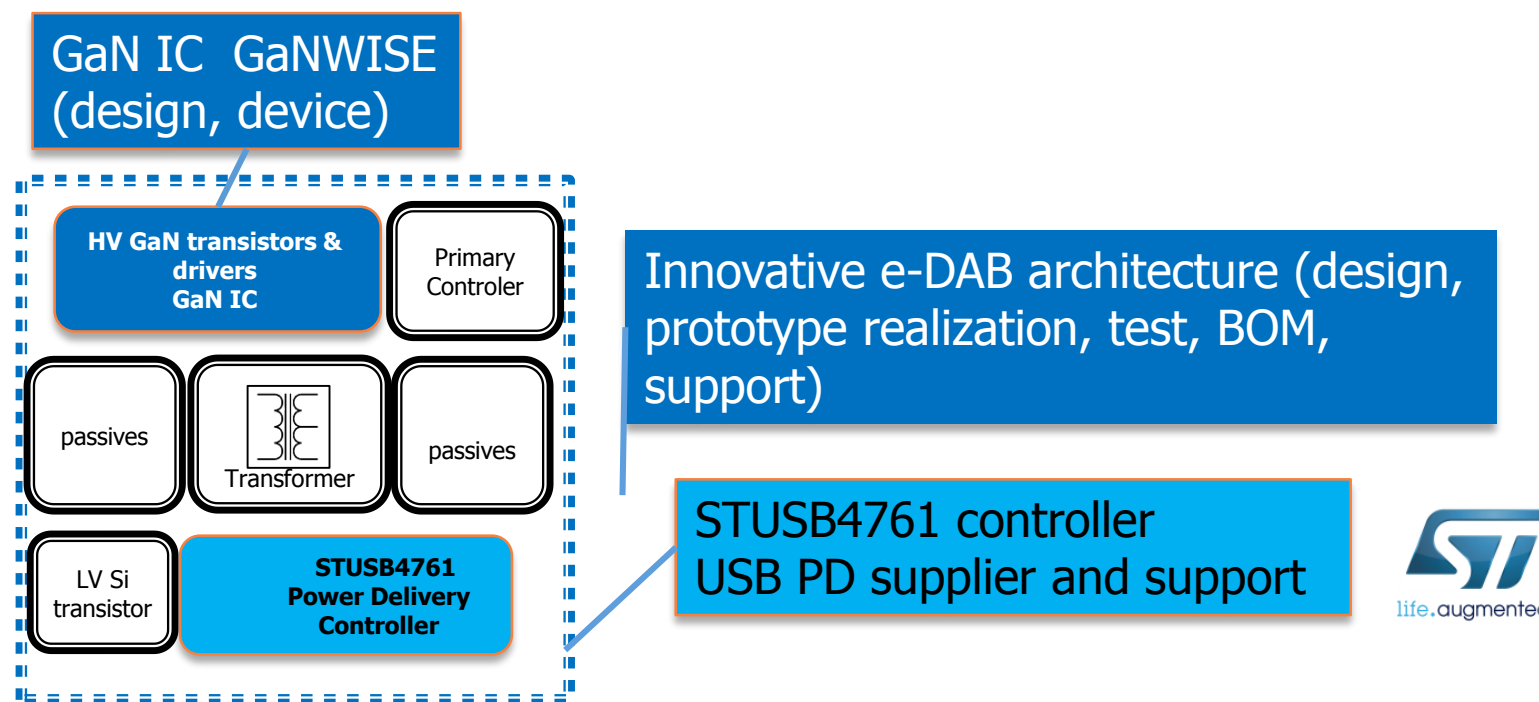
Package Outline

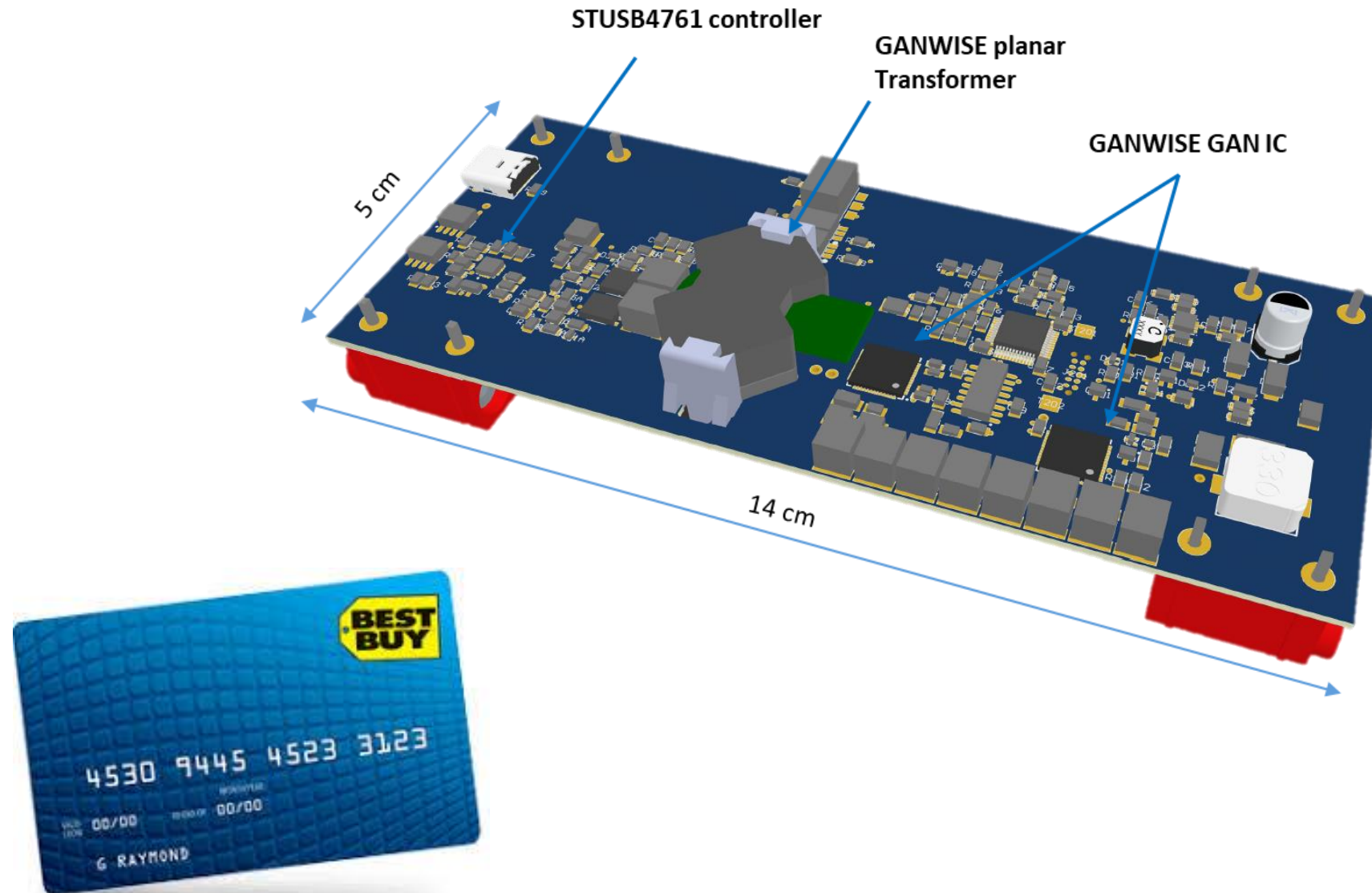


Circuit Symbol



- **Target is to validate the new innovative system topology with our first GaN IC**
  - 100W
  - 96% of efficiency (+2% vs actual state of the art)
  - Using new innovative ST controller STUSB4761 to manage USB C protocol
  - Design with EMI filters
  - Available for demonstration in April 2019





- What are the challenges to integrate ?



**Integration**  
**Limited volume of wall plug**

**Thermal dissipation**

**Robustness & device  
interoperability**

- How to integrate power block delivering 15W (smart phone) up to 60W -100W (computer / display / TV)?



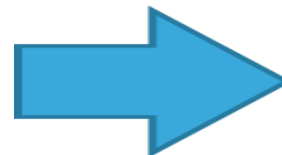
**Integration**  
**Limited volume of wall plug**



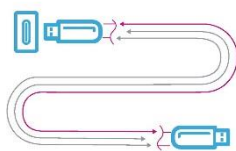
**GaN technology with innovative power**  
**GaN integrated circuit and system**  
**architecture**  
**(GANWISE GAN IC + e-DAB)**



**Thermal dissipation**



**Smart USB Power Delivery controllers**  
**with power sharing**  
**New discrete component technologies**



**Robustness &**  
**device interoperability**

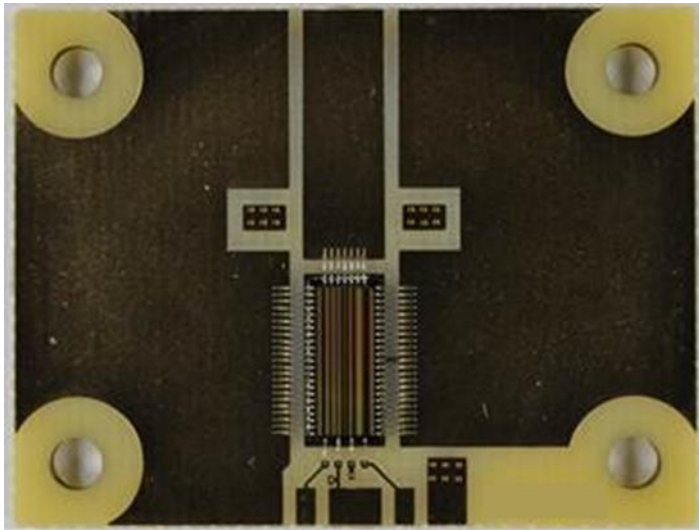


**Certified USB Power Delivery controllers**  
**Smart USB Power Delivery controllers with**  
**embedded protections**  
**(overvoltage / current / temp)**



- GaN is robust to radiation !

DC-DC converters for spatial market

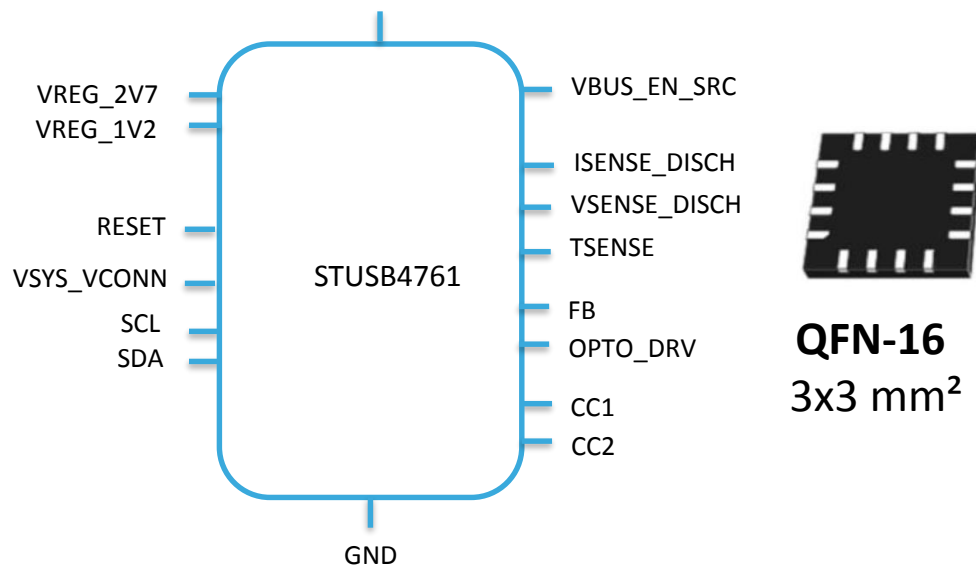


- GaN is working at high temperature > 200°C

Motor drive for industrial applications in harsh environment

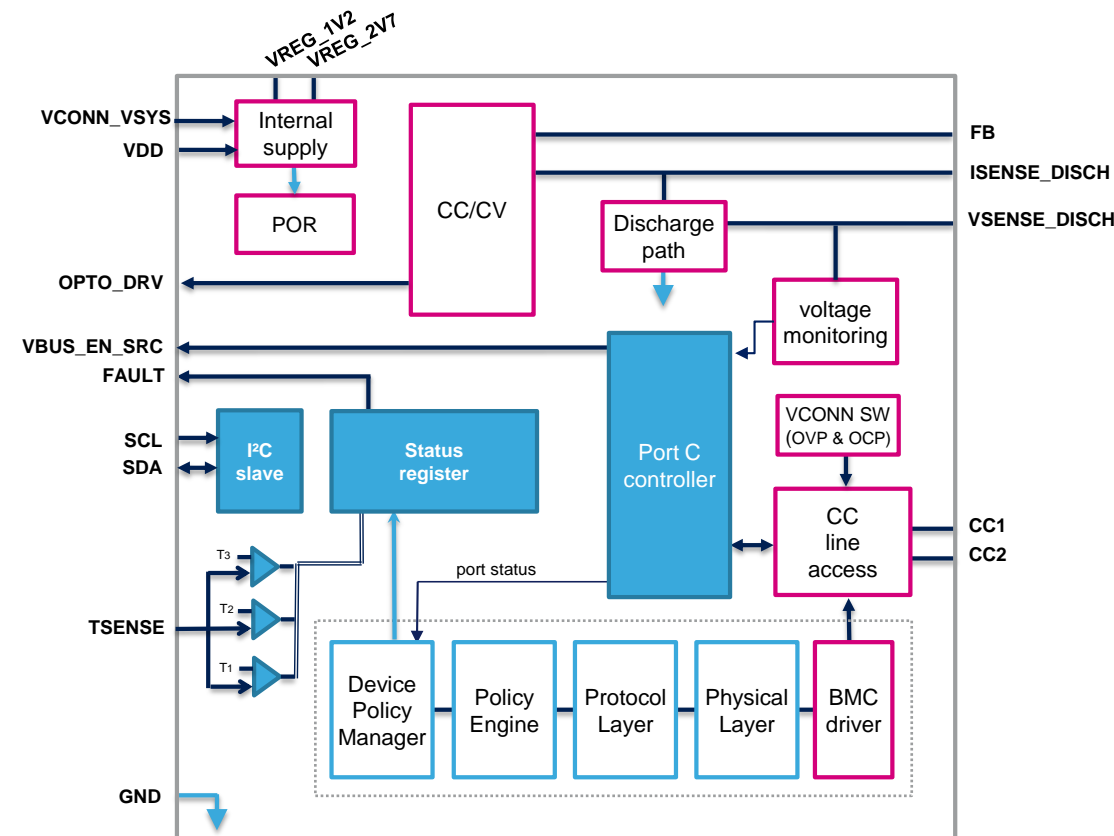


# Standalone USB PD controller STUSB4761 with integrated CC/CV for AC/DC applications

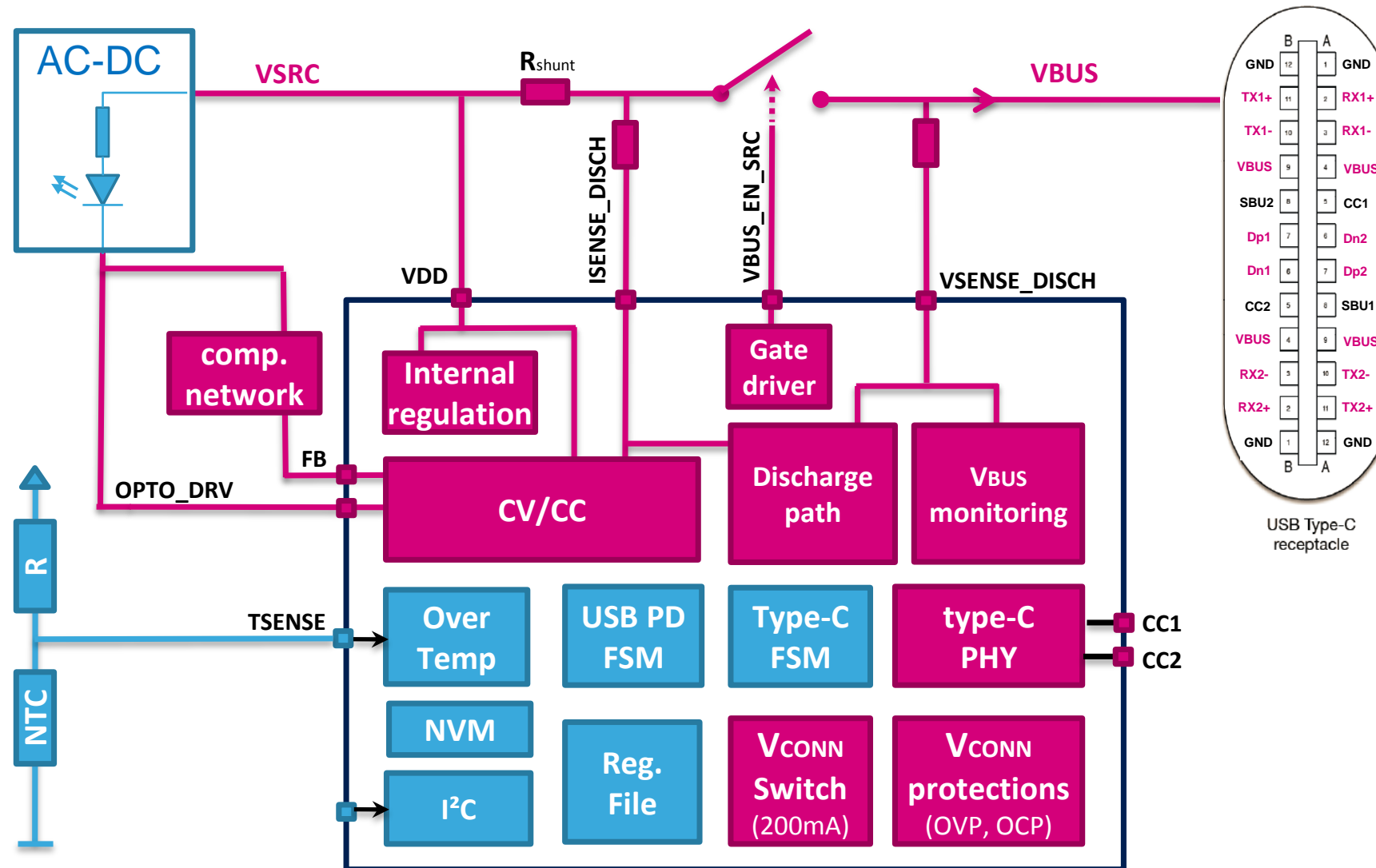


## Benefits

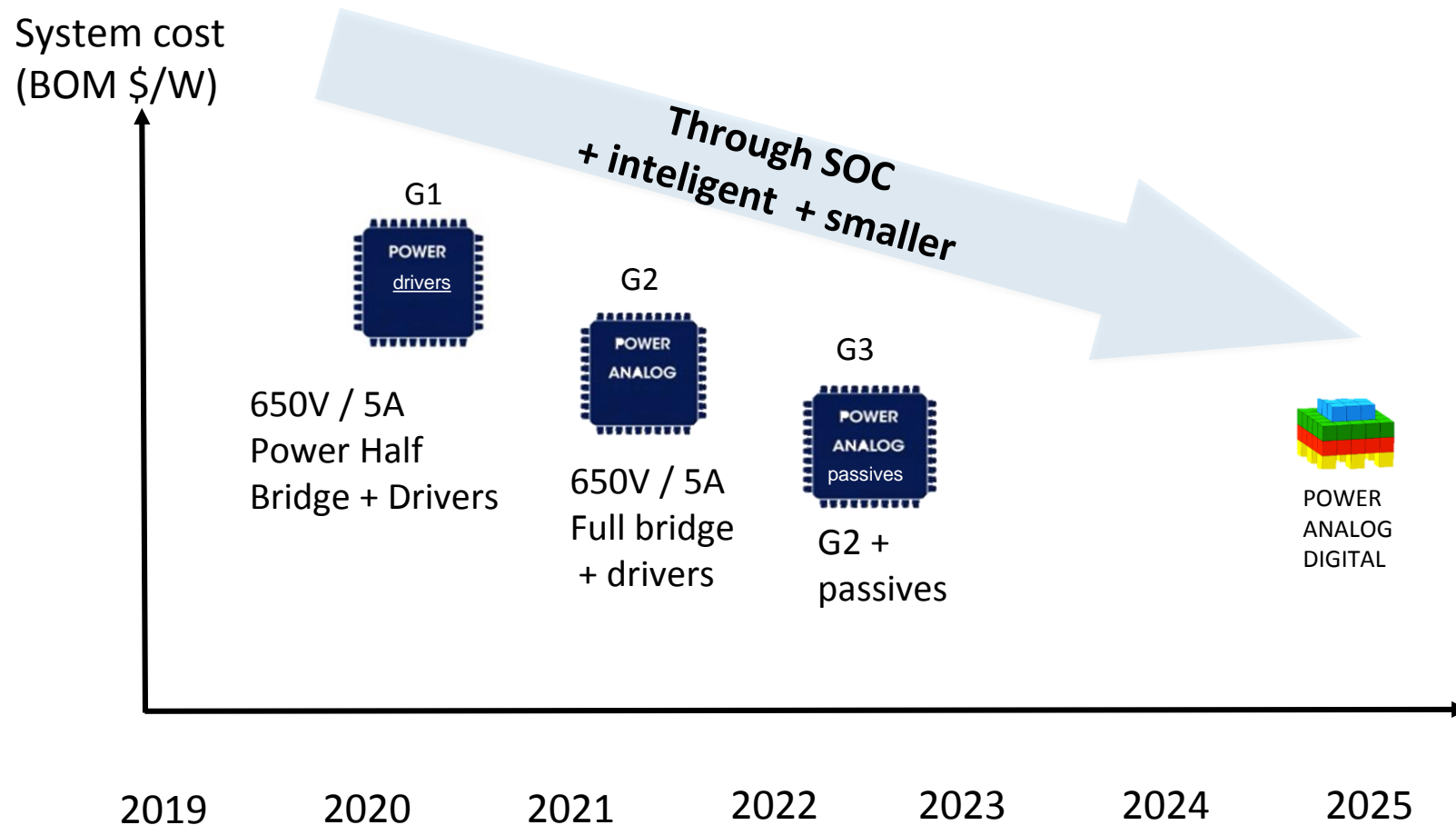
- No software skills required
- Robustness to high voltage
- Configurable and flexible
- Easy industrialisation
- reduced PCB area and cost versus discrete (small QFN 3x3 package)







- road map, next improvement steps and cost evaluation



# Thank You