

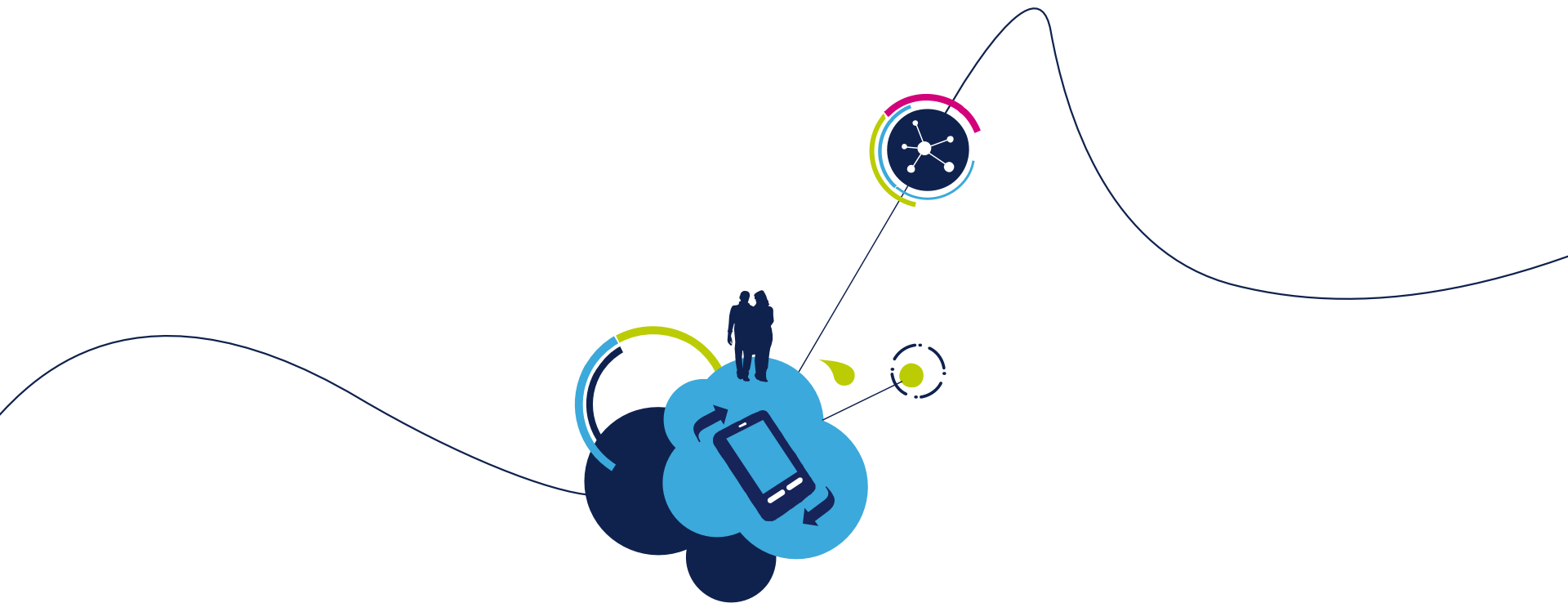


Power Supply topologies for Metering Applications

EMEA Marketing & Application team

Agenda

- Power supply requirements
- AC/DC topologies for single- and three-phase meters
- ST component selection and usage
- Application reference designs
- AC/DC converters & controllers
- DC/DC converters
- Low-dropout voltage regulators (LDOs)
- Power MOSFETs for Metering



Metering SMPS Requirements

Power supply requirements - Input

- Single phase
 - From 60 to 180 V_{AC}
 - To 265 to 300 V_{AC}
 - In short periods of time (6 hours – one week)
 - To 440 to 500 V_{AC}
 - Preferred single rectifier – for non-isolated SMPS
- Poly phase
 - From 60 to 180 V_{AC}
 - To 440 to 500 V_{AC}
 - Input connection
 - Bridge connection – SMPS works even if only 2 wires are connected
 - Single rectifier – SMPS stops working if the Neutral is disconnected
- Common requirements – high level of surge protection (4 to 6 kV)

Power supply requirements - Output

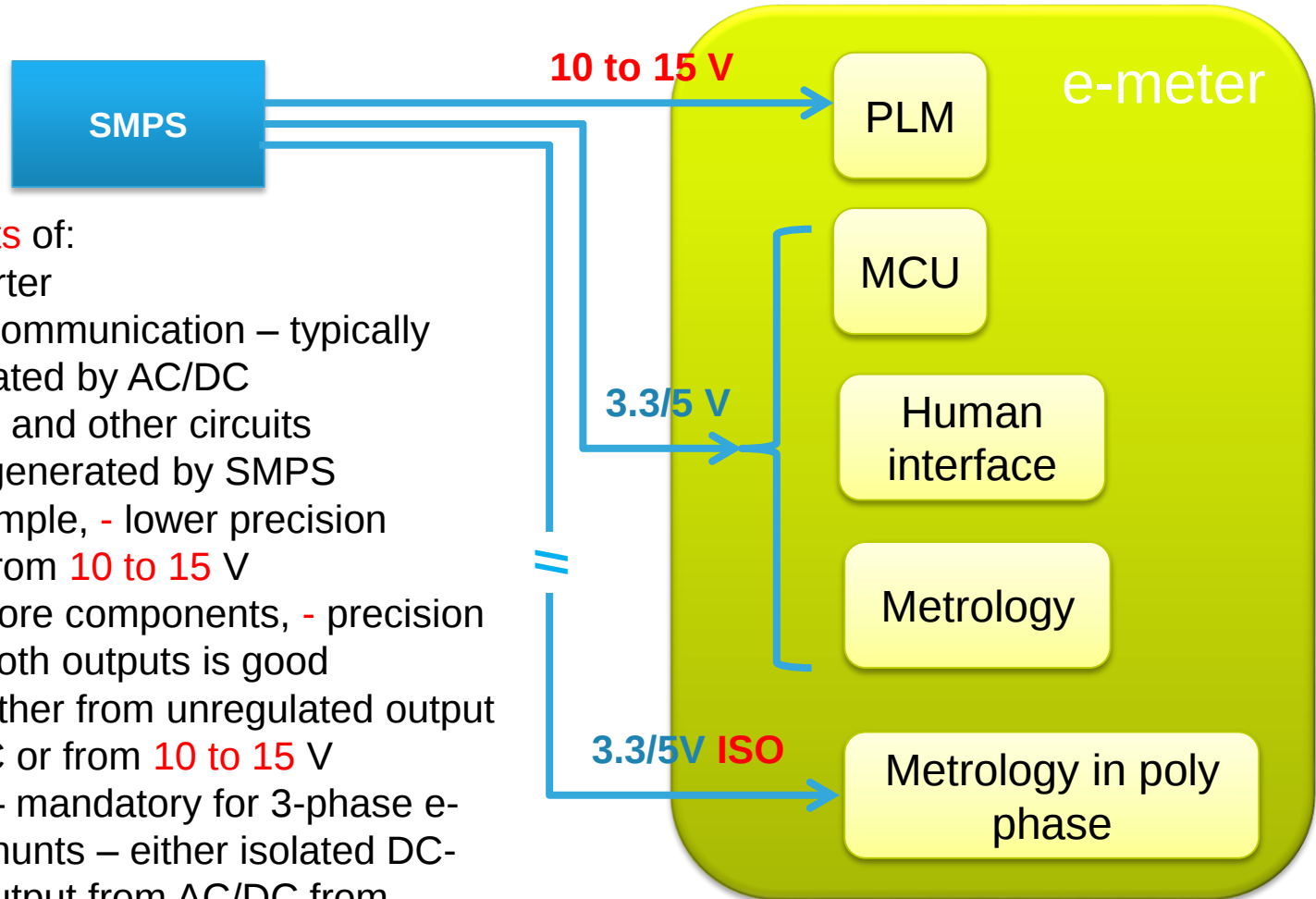
- Simple e-meter
 - No communication – only measurement and data processing
 - Output power: ~ 1 to 5 W
 - Output voltage: 3.3/5 V – typical supply for MCU, metering, and display
- Smart e-meter – includes communication – PLC, GSM
 - Output power
 - Average: 2 to 6 W
 - Peak power: up to 5 to 15 W
 - Output voltages: 3.3/5 V and 10 to 15 V
- Concentrator
 - Output power: 10 to 25 W
 - Output voltages: 3.3/5 V and 10 to 15 V



Power supply requirements - Others

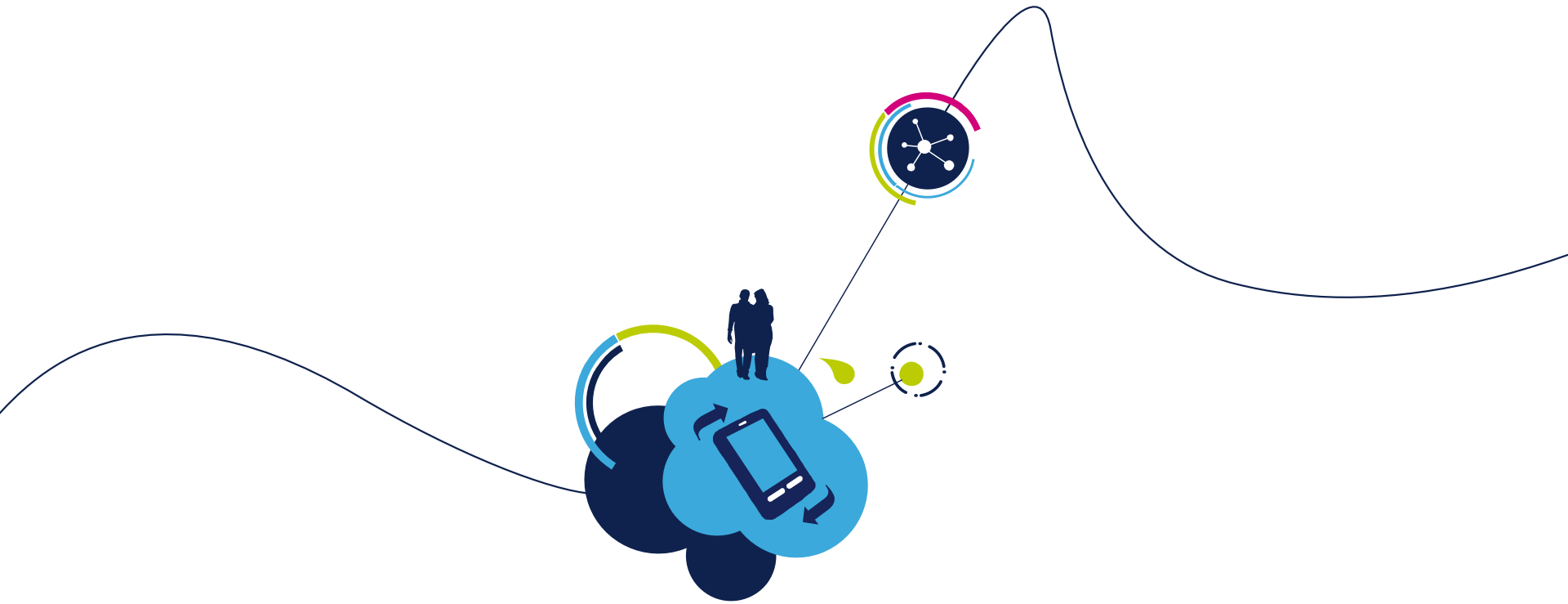
- Operating frequency
 - The communication frequency of Smart meters is typically between 60 and 100 kHz
 - Therefore, the preferred operating frequency is > 100 kHz
- Magnetic field immunity
 - The SMPS must be able to survive magnetic fields up to 0.5 T!!!
 - Distance of field source to SMPS – several centimeters
 - Typically the SMPS must survive, but operation can be halted
 - In certain cases, limited operation may also be required in this condition

E-meter supply topology



An SMPS consists of:

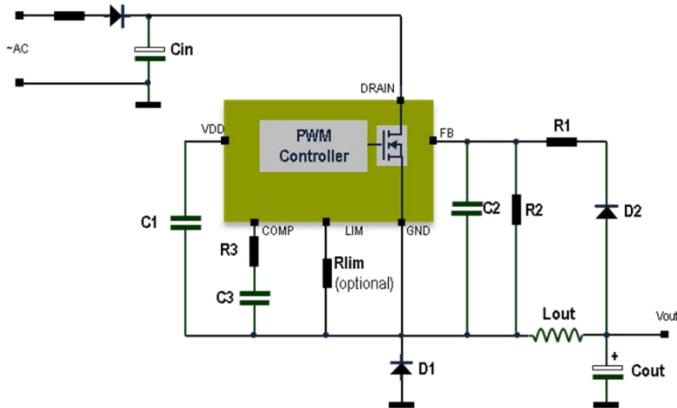
- AC/DC converter
- 10 to 15 V – communication – typically directly generated by AC/DC
- 3.3/5V – MCU and other circuits
 - Directly generated by SMPS
 - + simple, - lower precision
 - DC-DC from 10 to 15 V
 - + more components, - precision of both outputs is good
 - LDO – either from unregulated output of AC/DC or from 10 to 15 V
- 3.3V/5V ISO – mandatory for 3-phase e-meter using shunts – either isolated DC-DC or other output from AC/DC from transformer



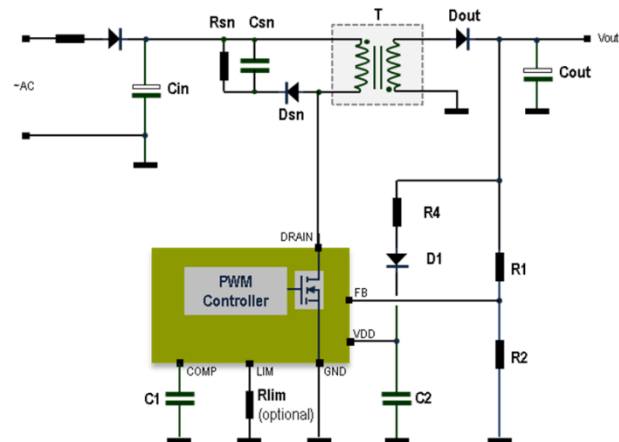
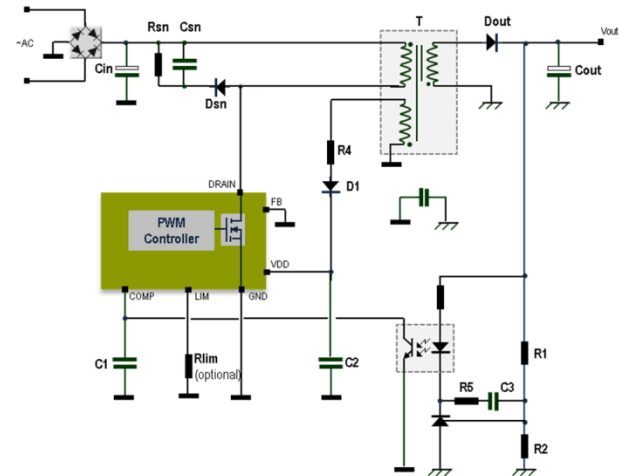
AC/DC - Topologies

AC/DC Topologies applicable for Metering SMPS

BUCK converter – eMeters



FLYBACK converter SMART meters and Concentrators



Buck Converter Limitations and Advantages

- Output

- 5 to 15 V, up to 300 mA (Viper26)
- Tolerance ± 1 V

- Input

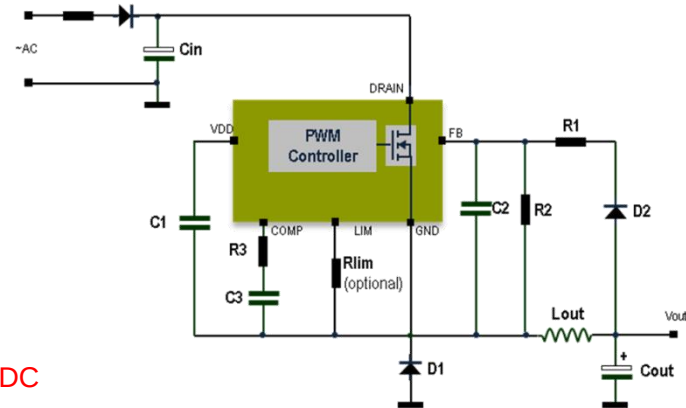
- Considering 100 V surge pulse up to 700 V_{DC}
- It means 500 V_{AC}
- Minimum voltage from 40 V_{DC} (Viper06) to 100 V_{DC} (Viper26)

- Operating frequency

- 30 or 60 kHz for Viper06
- 60 kHz for Viper16 or Viper26
- 115 kHz recommended only in case of 15 V output and no operation in CCM

- Applicable components

- Viperx6, Viperx1



Flyback Converter Limitations and Advantages

- Output

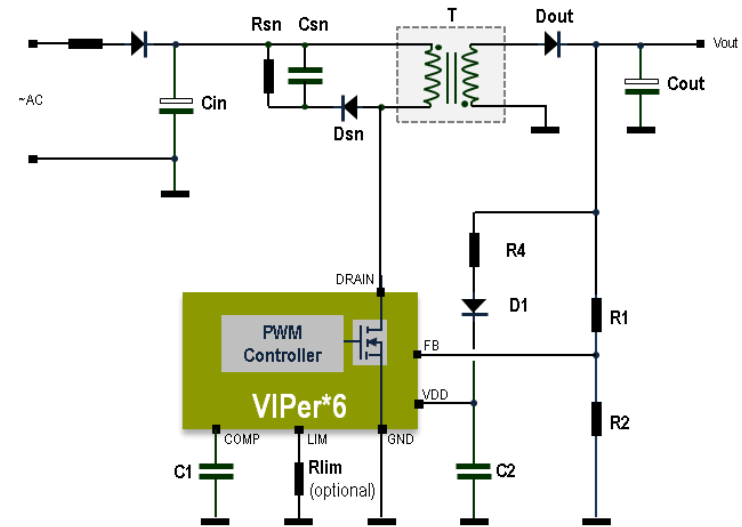
- Any voltage (typically 3.3V and 15V)
- Simple to realize more outputs
- High precision for one output ($\pm 3\%$)
- Power
 - Altair04-900: 4 to 12 W (peak)
 - Viperx1/6: 12 to 20 W
 - L6566BH: Up to 30 W (in fact, not limited)

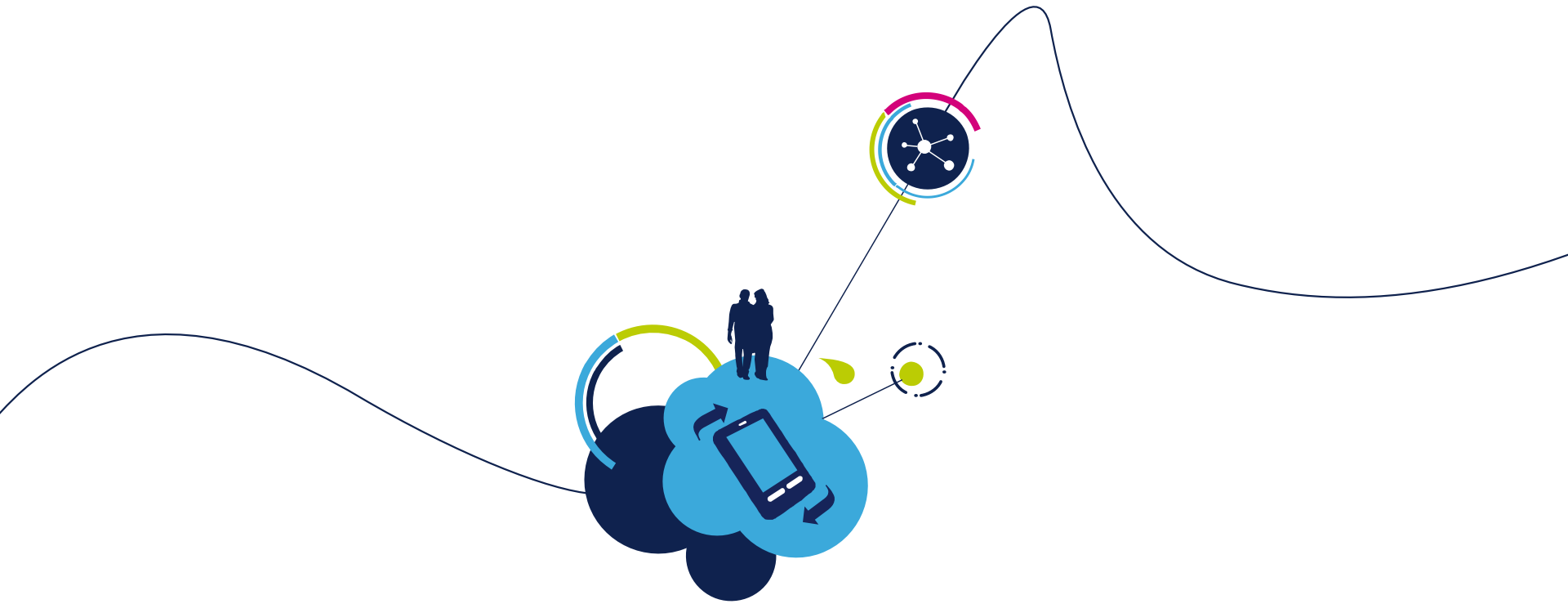
- Input maximum

- Viper: Up to 440 V_{AC} for a limited time
- Altair04-900: Up to 460 V_{AC} (permanent connection)
- L6566BH + 950V/1.2kV MOSFET: Up to 500 V_{AC}

- Operating frequency

- Typically above 100 kHz (115 kHz, 100 to 130 kHz)

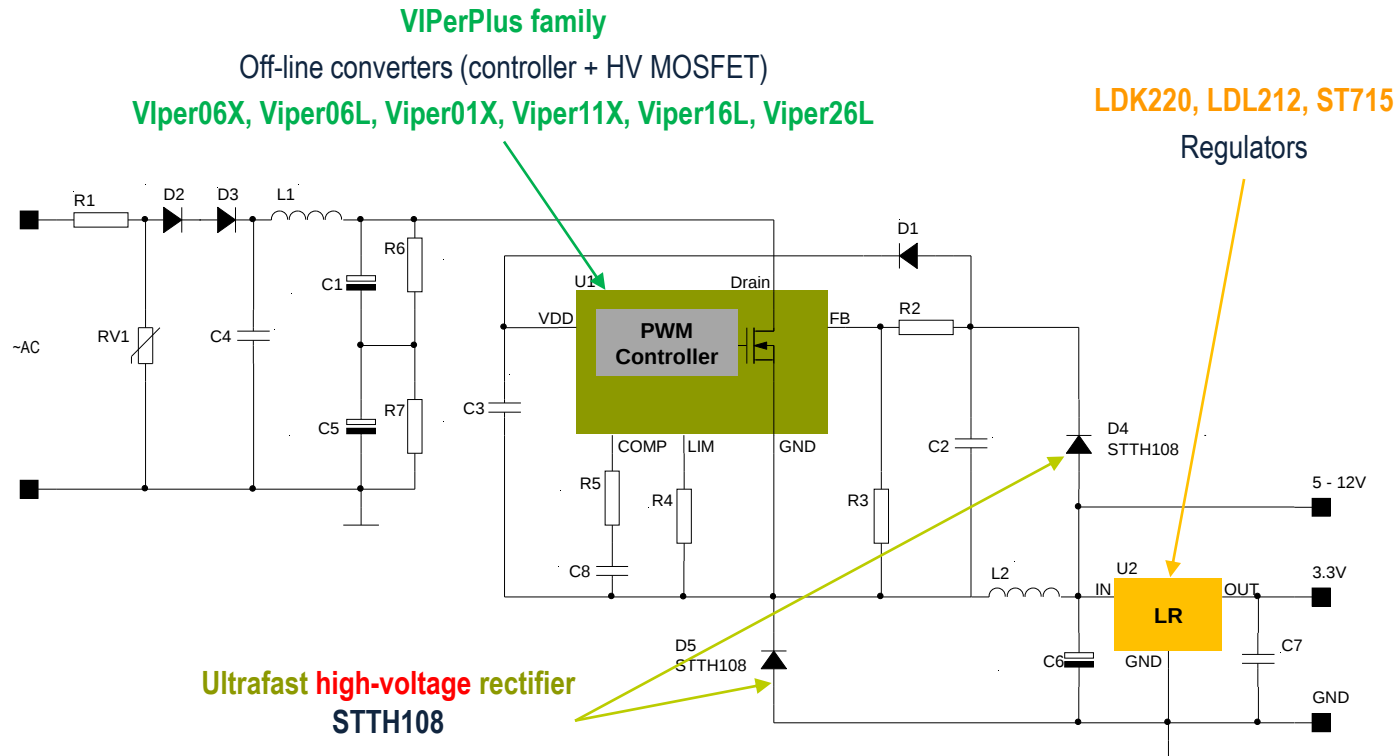




ST components selection and usage

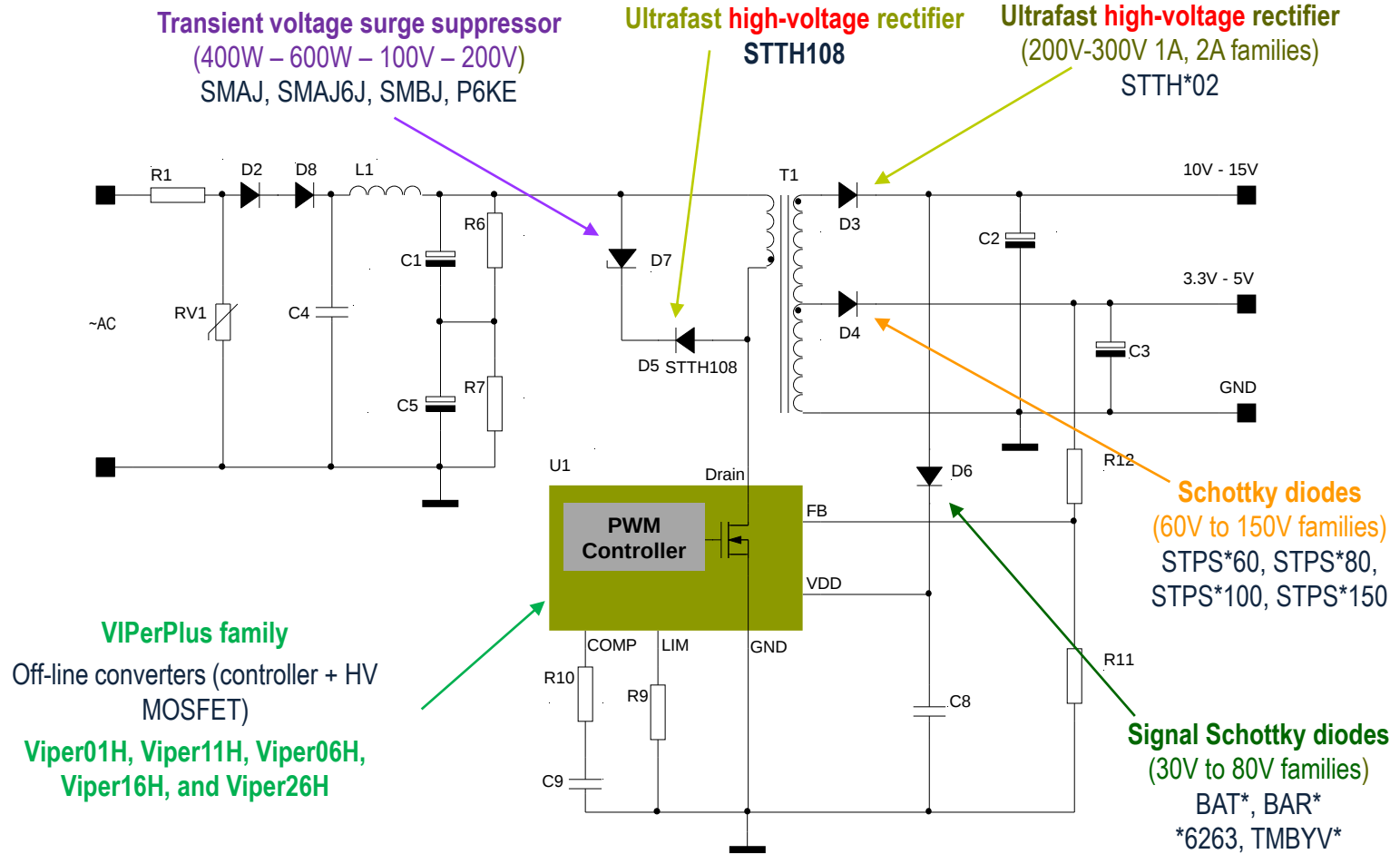
Simple e-Meter – Buck converter

Monolithic solution



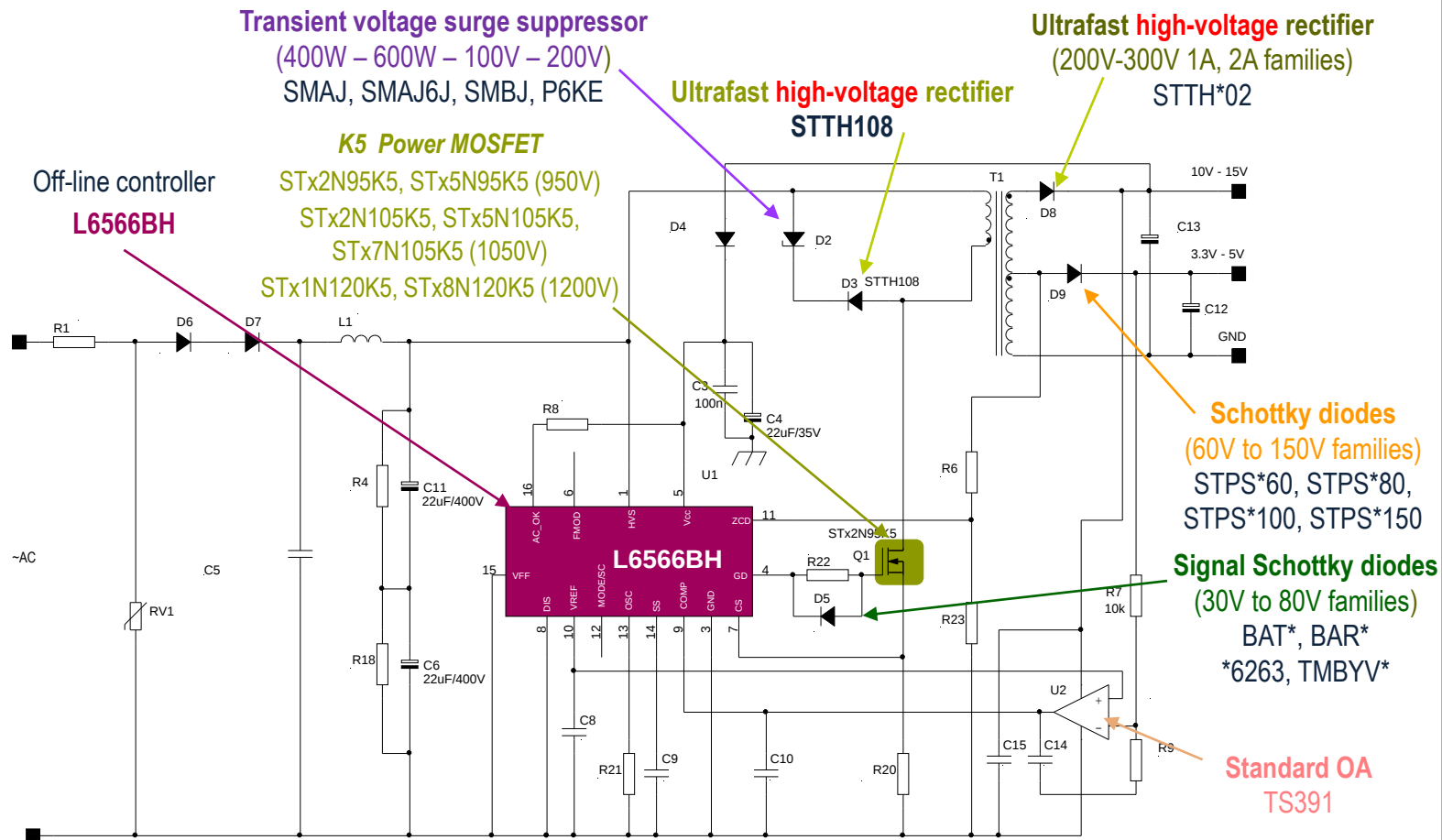
1- phase meter, Concentrator – Flyback no isol.

Monolithic solution – limitation 800V MOSFET



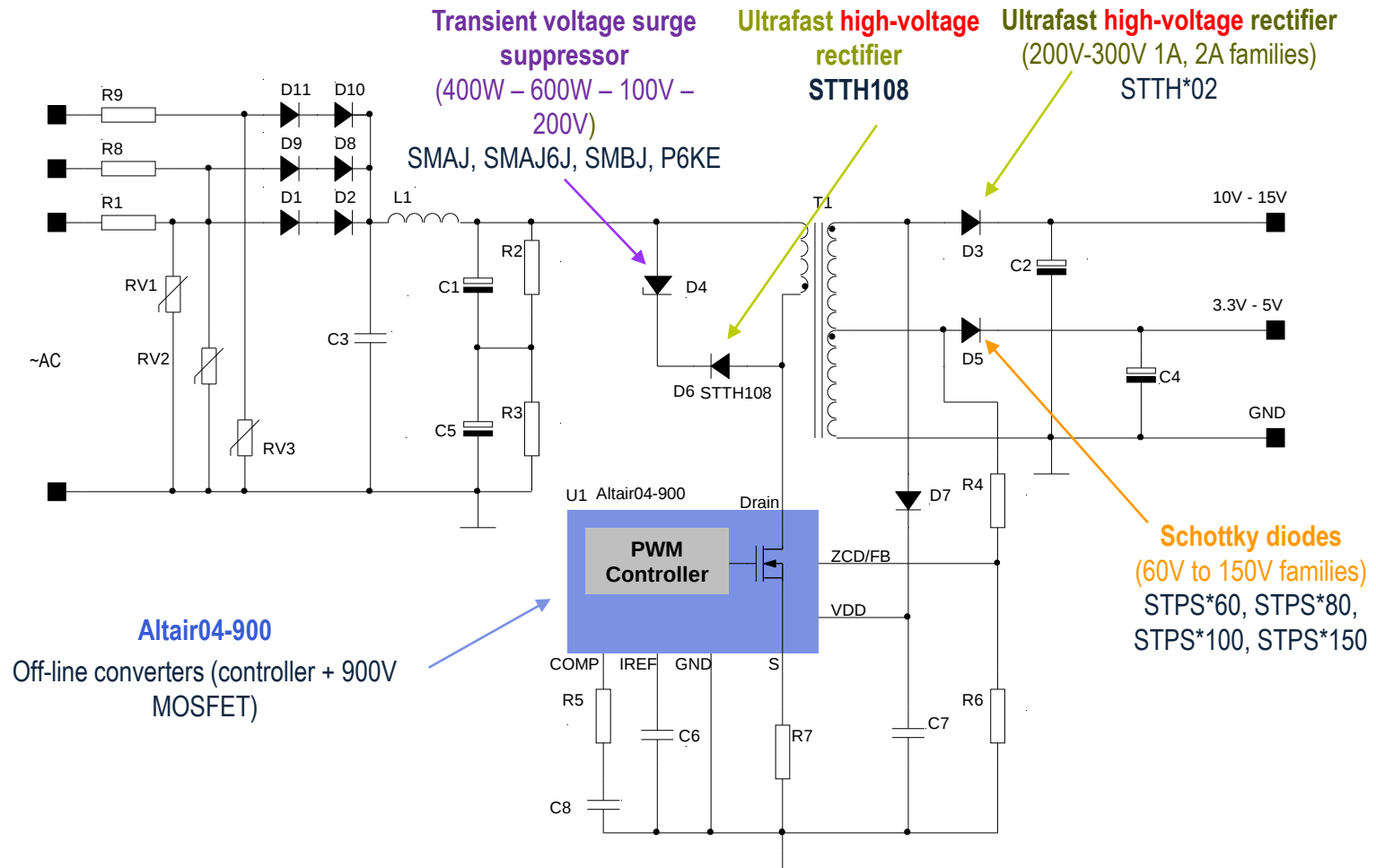
1- phase meter, Concentrator – Flyback no isol

Discrete solution – MOSFET up to 1.5 kV available, drawback higher complexity



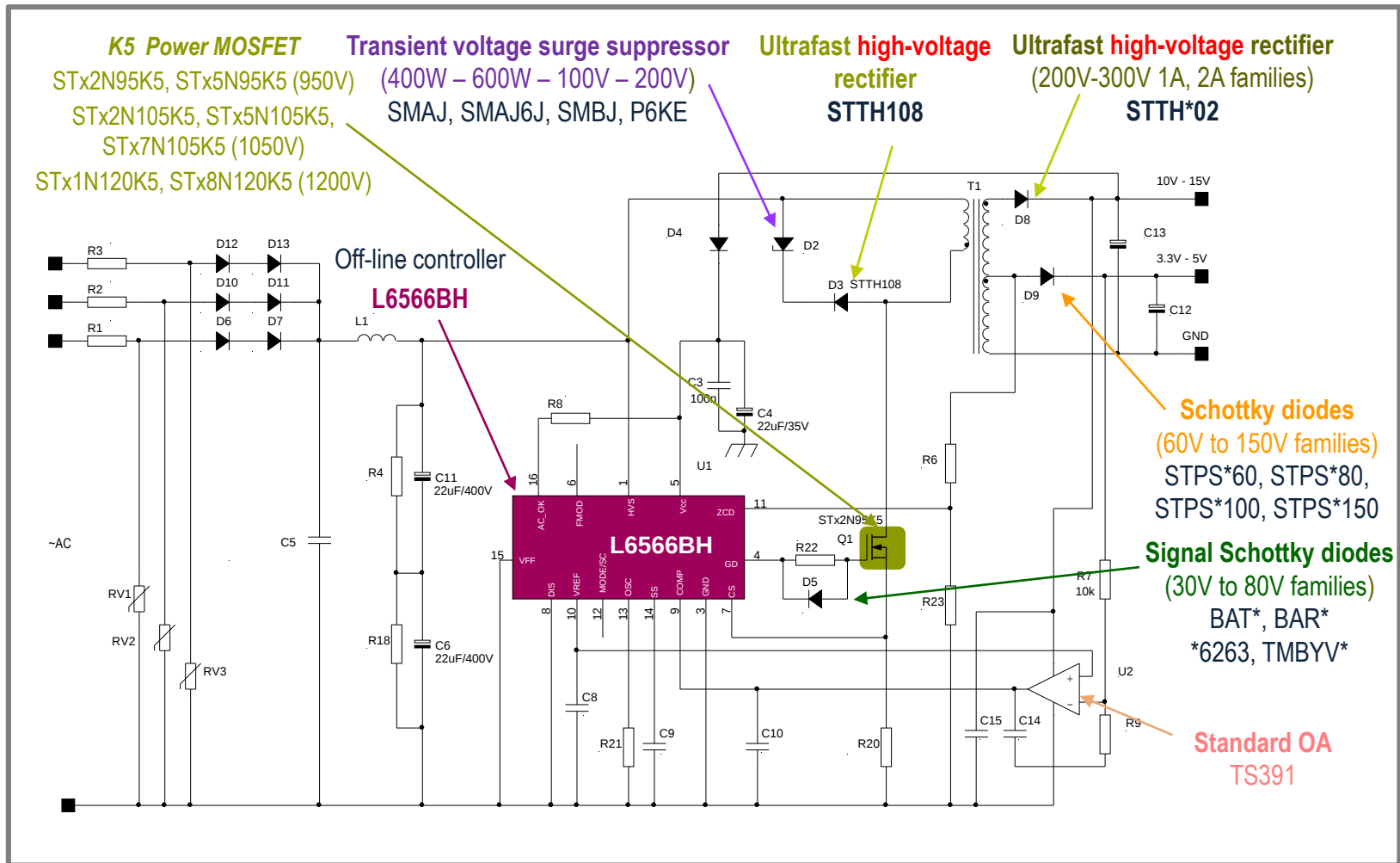
3-phase meter – Flyback, single rectifier

Monolithic solution – simple, drawback peak power limited up to 8 – 9W



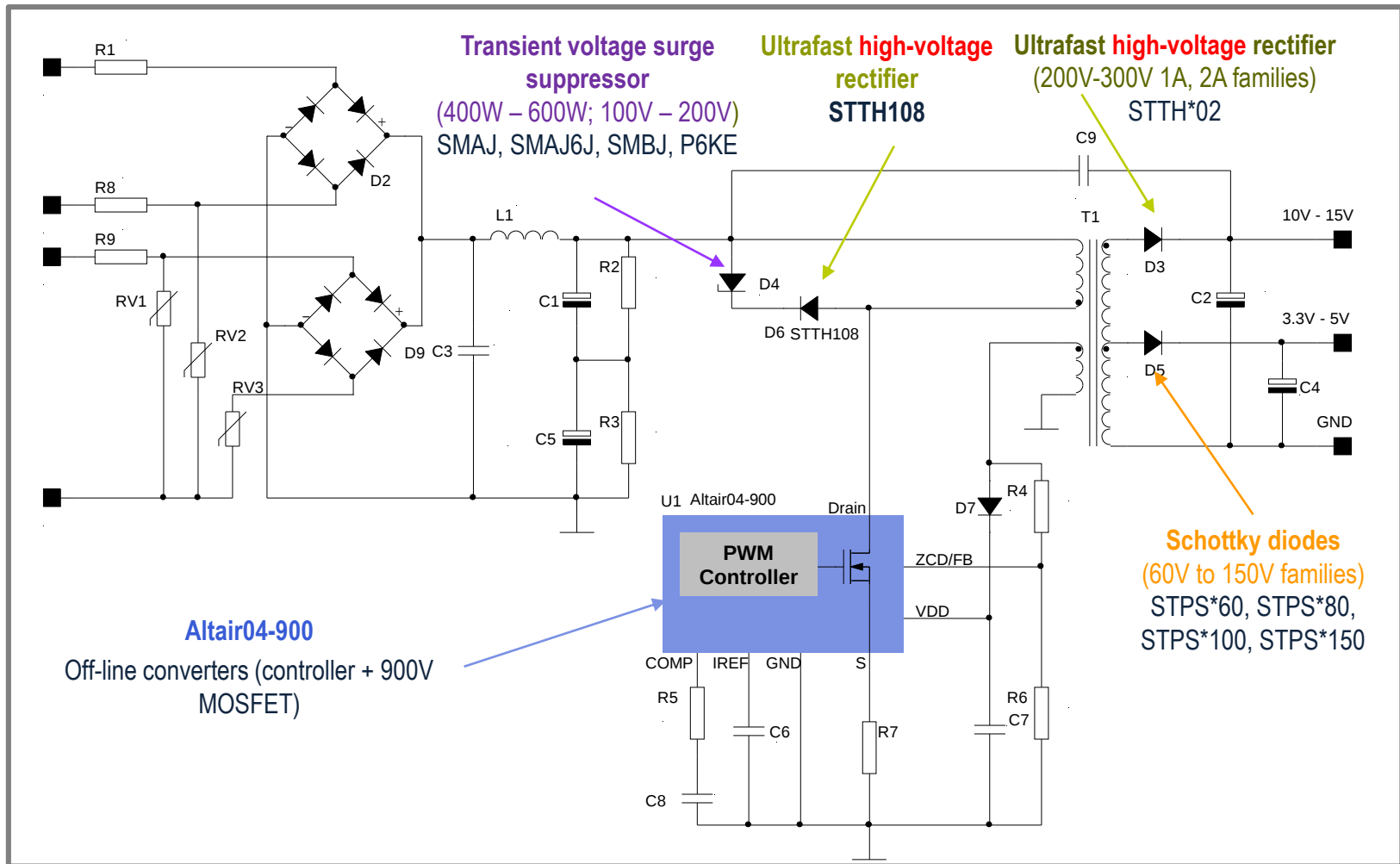
3-phase meter – Flyback, single rectifier

Discrete solution – **MOSFET** up to 1.5 kV available, no power limitation, drawback higher complexity



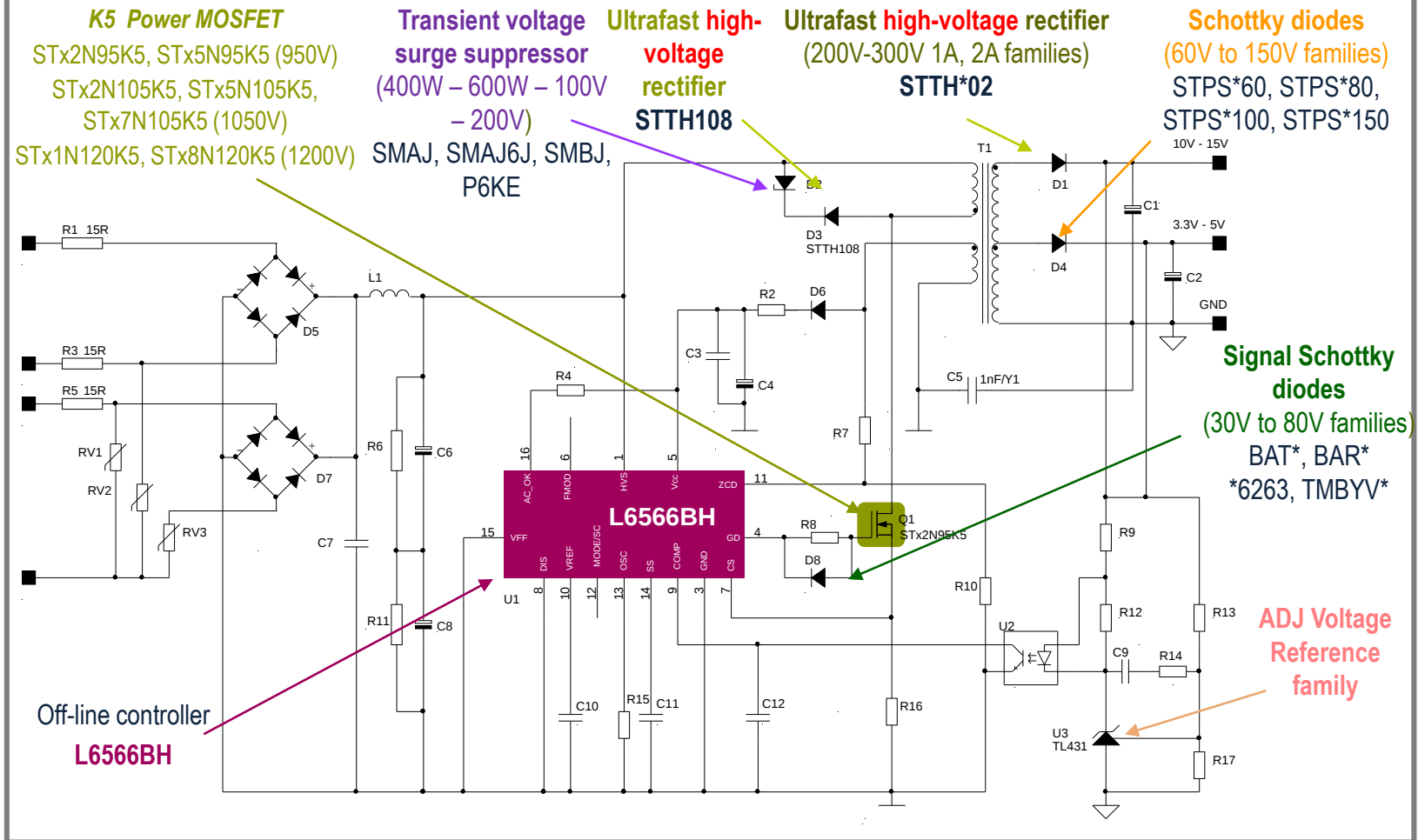
3-phase meter – Flyback, bridge rectifier

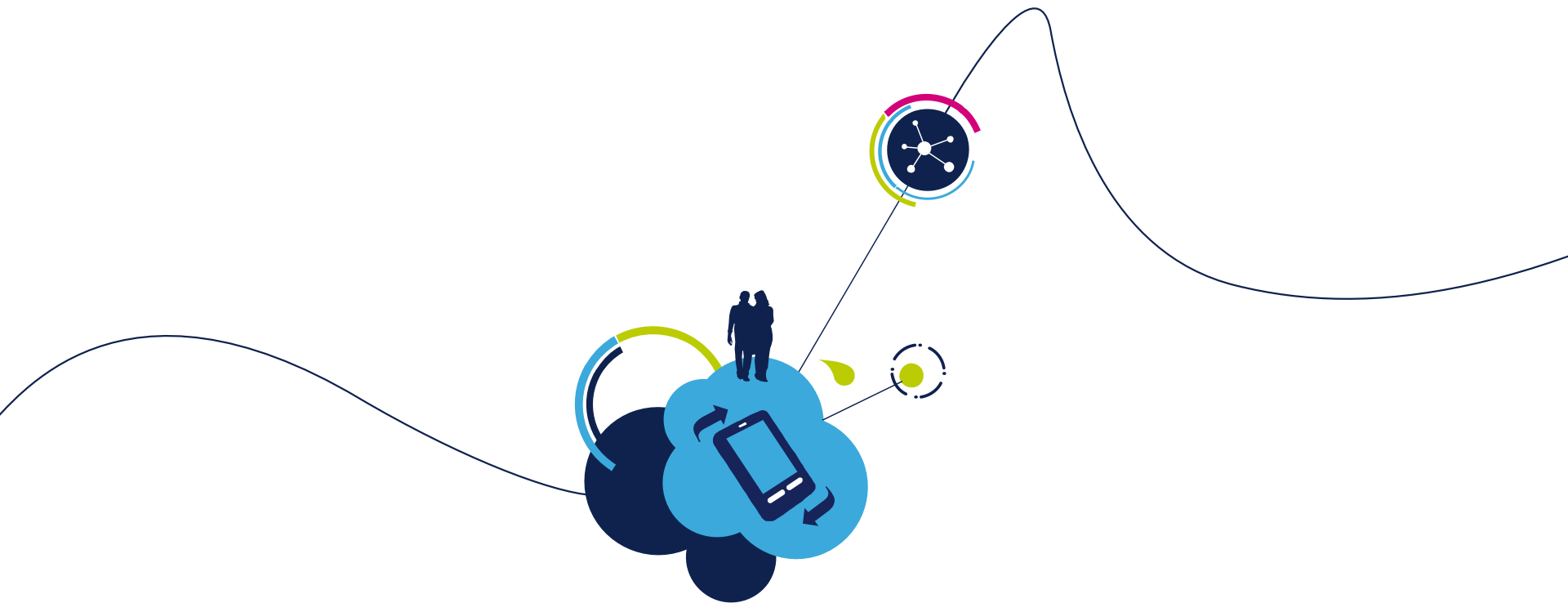
Monolithic solution – simple, drawback peak power limited up to 8 – 9W



3-phase meter – Flyback, bridge rectifier

Discrete solution – **MOSFET** up to 1.5 kV available, no power limitation, drawback higher complexity





Reference designs

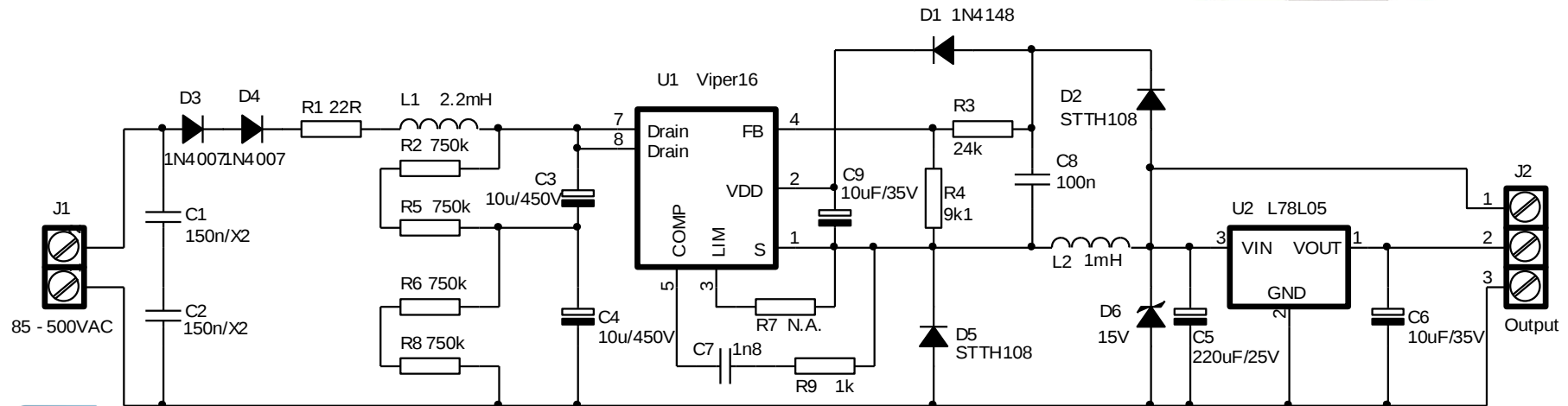
Demo board - STEVAL-ISA010V1

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Super Wide Input Range Viper16 Buck Converter

Documentation: AN2872

- Buck topology
- Common Neutral
- Input voltage range: 85 to 500 V_{AC}
- Output voltages: 12V and 5V
- Output current (max.): 150 mA (total for both outputs)
- Conductive EMI EN55022 Class B
- Stand-by less than 100 mW at 230 V_{AC}



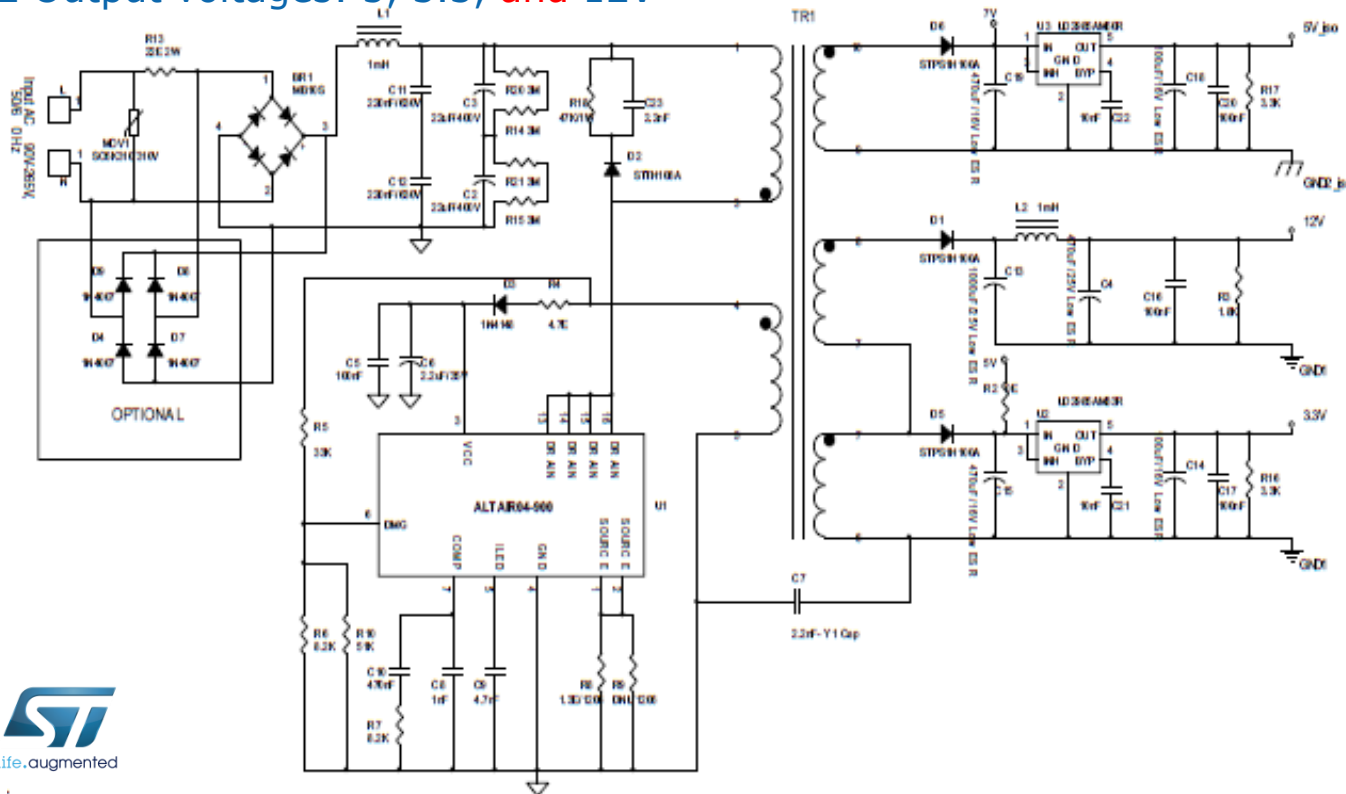
Demo board - STEVAL-ISA105V1

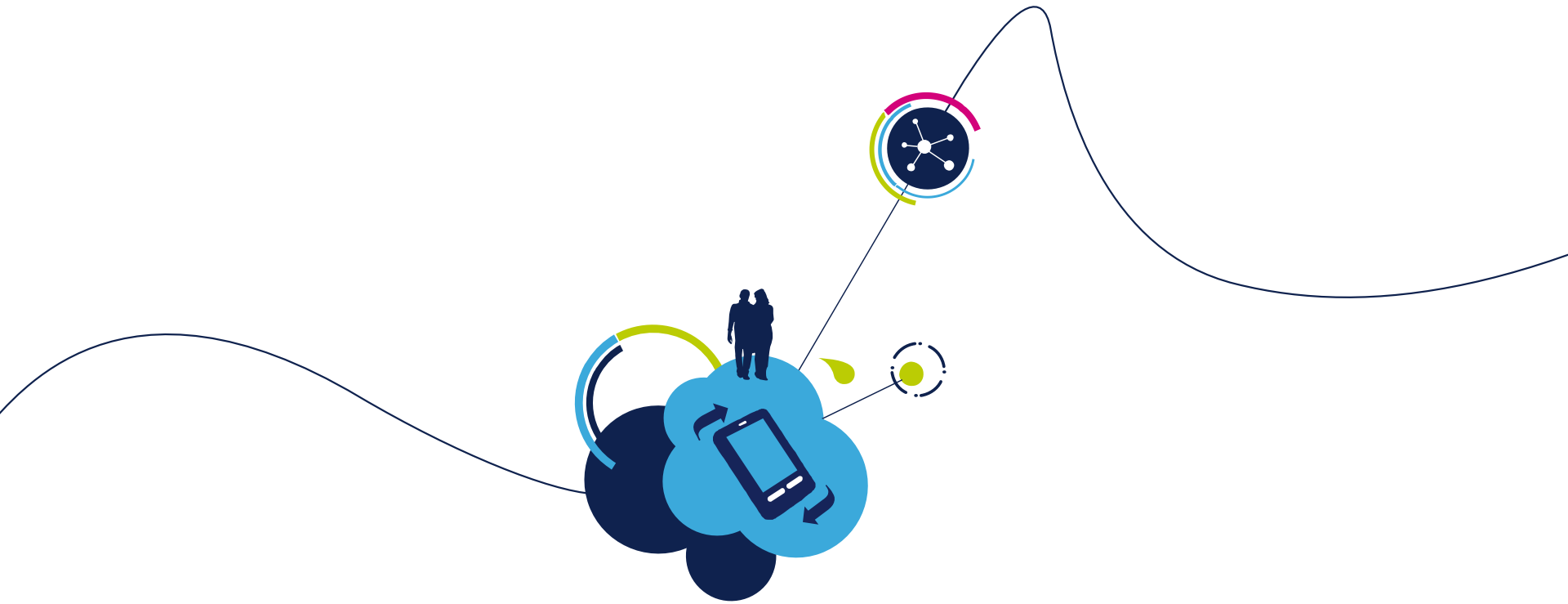
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Power supply for energy meter and power line modem based on Altair04-900

Documentation: AN4154

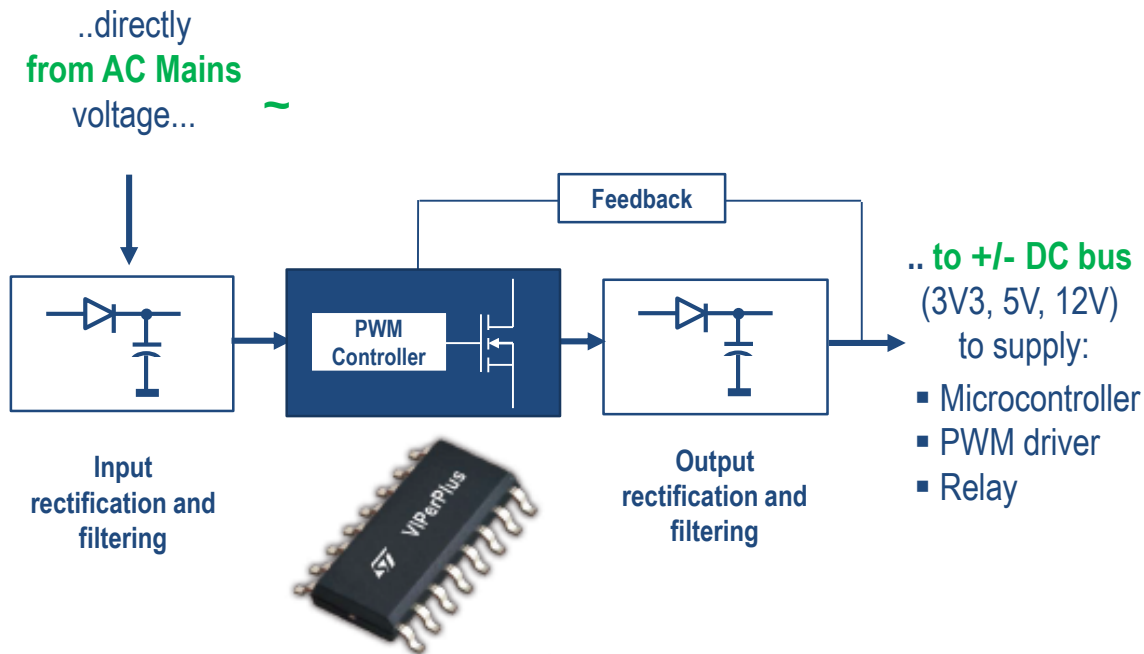
- Flyback
- Input voltage range: 90 to 480 V_{AC}
- Output power: 7W peak
- Output voltages: 5, 3.3, and 12V





AC-DC converters and controllers

Advanced controller with embedded **800V** Power MOSFET



Robustness and Reliability

800V Power MOSFET, thermal shutdown, soft start, OLP protection, auto-restart



Energy saving

Power consumption less than 30mW at no load



High integration

Direct feedback, jittering, HV start-up



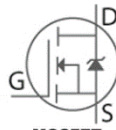
Flexibility

power scalability up to 12W, no auxiliary winding, clamp-less design, no CM EMC filter

ST Offline Converters Overview

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Buck Converter	150mA	200mA	350mA	
Fly-back Converter	5W	8W	12W	15W
85-265VAc				

800V		32Ω 350mA	24Ω 400mA	20Ω 480/600 mA	19Ω (900V) Ext RSENSE	14Ω Ext RSENSE	7Ω 700mA	4.5Ω 1 / 1.15A
MOSFET								

VIPerPlus0P

VIPer0P

VIPerPlus*1

VIPer01

New

VIPer11

H2 2018

VIPerPlus*5

VIPer25

VIPer35

VIPerPlus*6

VIPer06

VIPer16

VIPer26

VIPerPlus*7

VIPer17

VIPer27

VIPer37

VIPerPlus*8

VIPer28

VIPer38

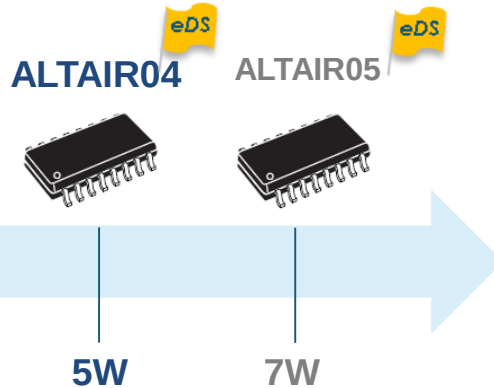
Altair0*

900V

Altair 04

Altair 05

ALTAIR family: Off-line all-primary sensing switching regulator

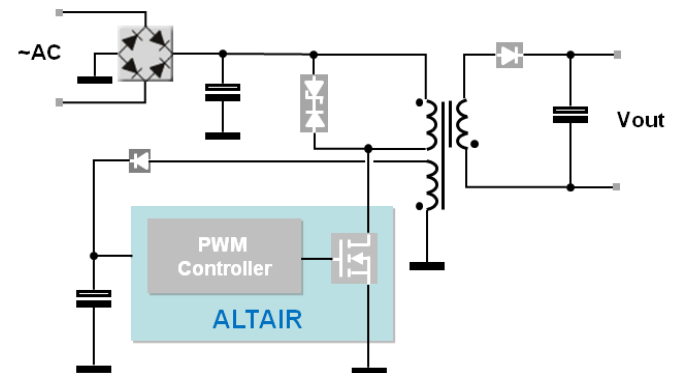


Maximum output power for $V_{IN} = 85 \text{ to } 265 \text{ V}_{AC}$

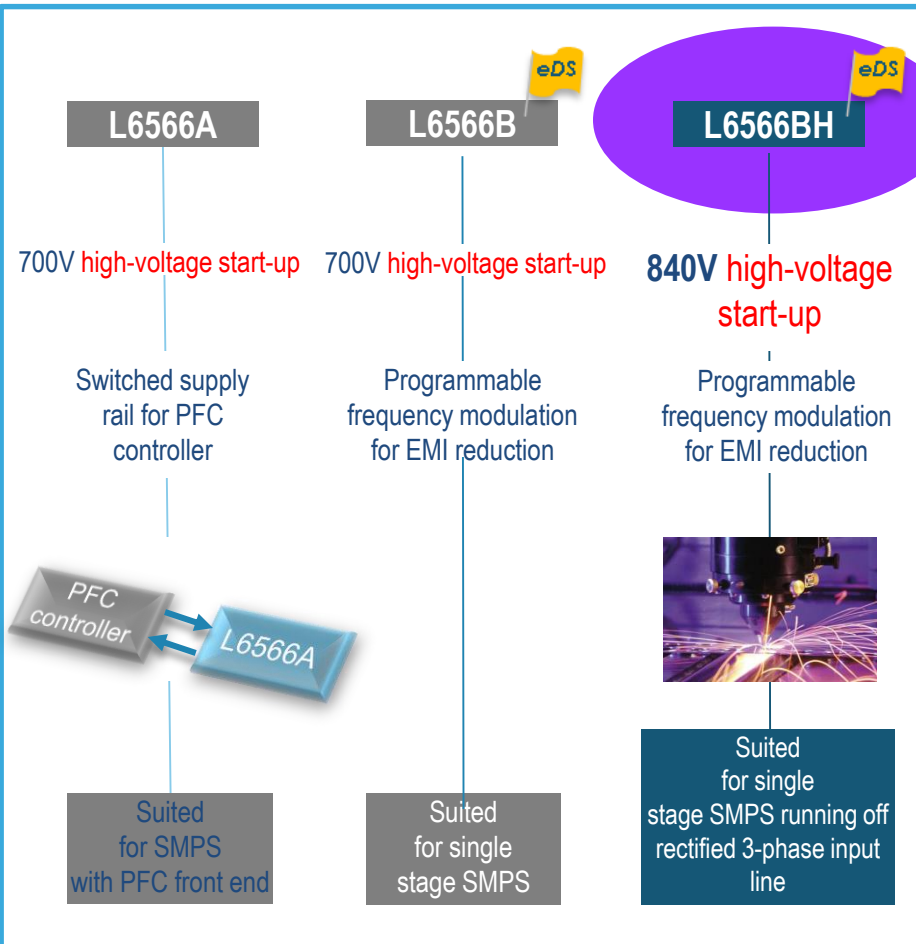
	ALTAIR04	ALTAIR05
Breakdown voltage	900 V	800 V
Resistance Drain Source ($T_j = 25^\circ\text{C}$)	16 Ω	11 Ω
Minimum Drain start-up voltage	50 V	50 V
Supply voltage range	11.5 to 23 V	11.5 to 23 V

Main features

- CC/CV regulation with no opto-coupler
- Avalanche rugged internal power MOSFET
- Internal HV start-up circuit
- Quasi-resonant ZVS operation
- Valley skipping at medium-light load
- Burst mode operation at no-load for under 60 mW consumption
- Automatic self-supply
- Input voltage feed-forward for mains-independent CC regulation
- Overcurrent protection against transformer saturation and secondary diode short circuit
- Low quiescent current ($< 1 \text{ mA}$)

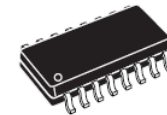


L6566 family: Multi-mode controllers

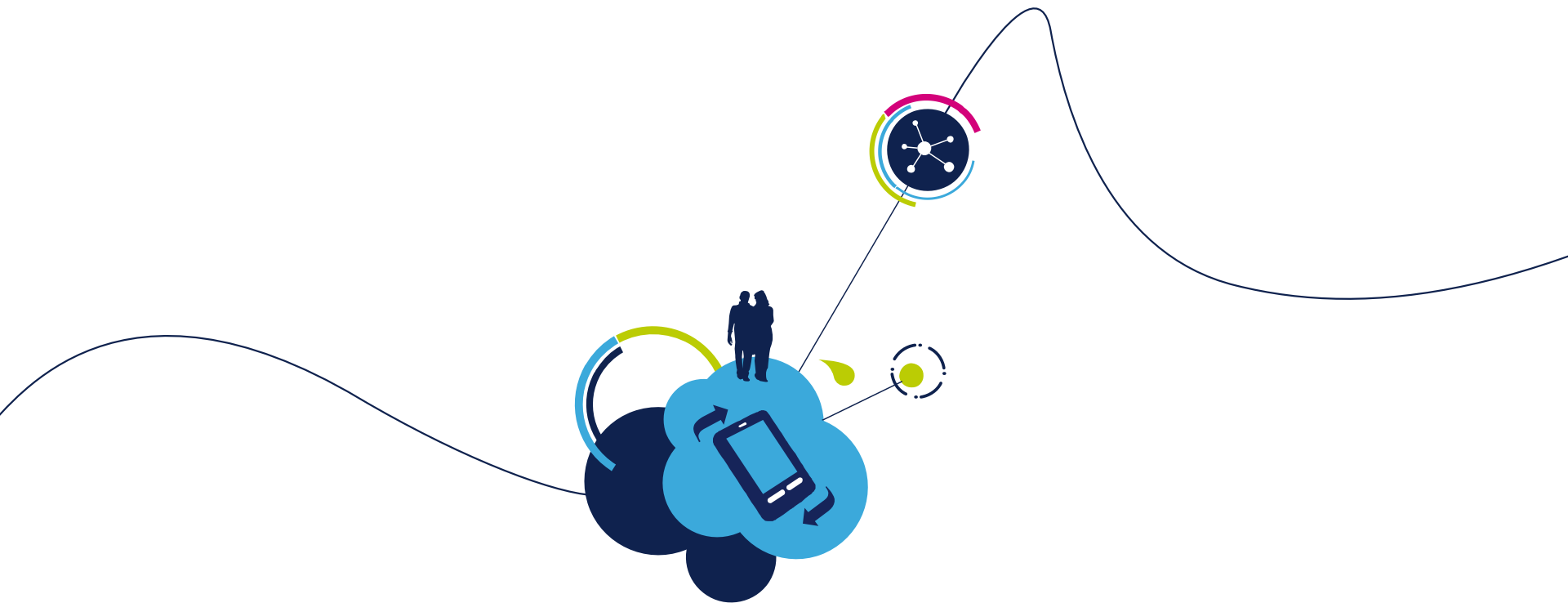


Common features

- Fixed frequency or quasi resonant operations
- Advanced light load management
- **On-board high-voltage start-up generator**
- Low quiescent current (< 3 mA)
- Adaptive UVLO
- Line **feed-forward** for constant power capability vs mains voltage
- Pulse-by-pulse **OC**P, shutdown on overload (latched or auto-restart)
- Transformer saturation detection
- Latched or **auto-restart** OVP
- Brownout protection
- -600/+800 mA totem pole gate driver with active pull-down during ULVO
- SO16N package



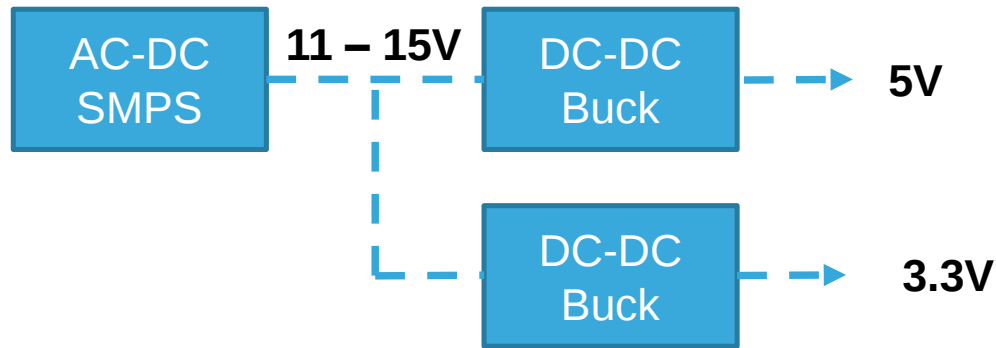
Controllers with selectable quasi-resonant (QR) or **fixed-frequency** (FF) operation



DC-DC converters

DC-DC – post regulation

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ST1S4x ST1S5x

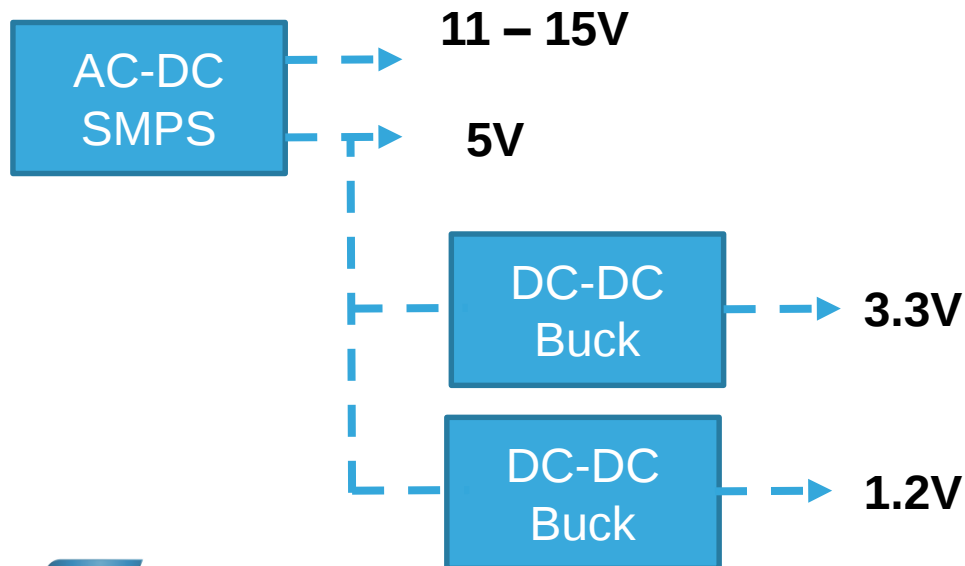
L6984

High-efficiency (Sync. Rect.)

Low BOM

Cost-effective

Low Stand-by Consumption (ST1S5x)



ST1S31/32, ST1S12

(ST1S4x and ST1S5x)

High-efficiency (Sync. Rect.)

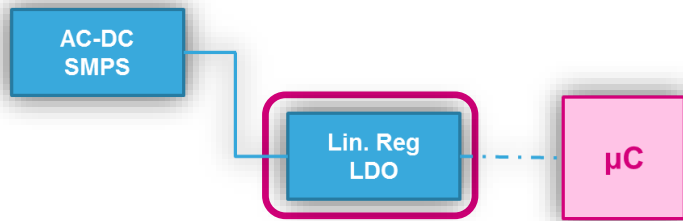
Low BOM

Cost-effective

Low Stand-by Consumption (ST1S5x)

Linear Regulators: Low quiescent current LDOs

30

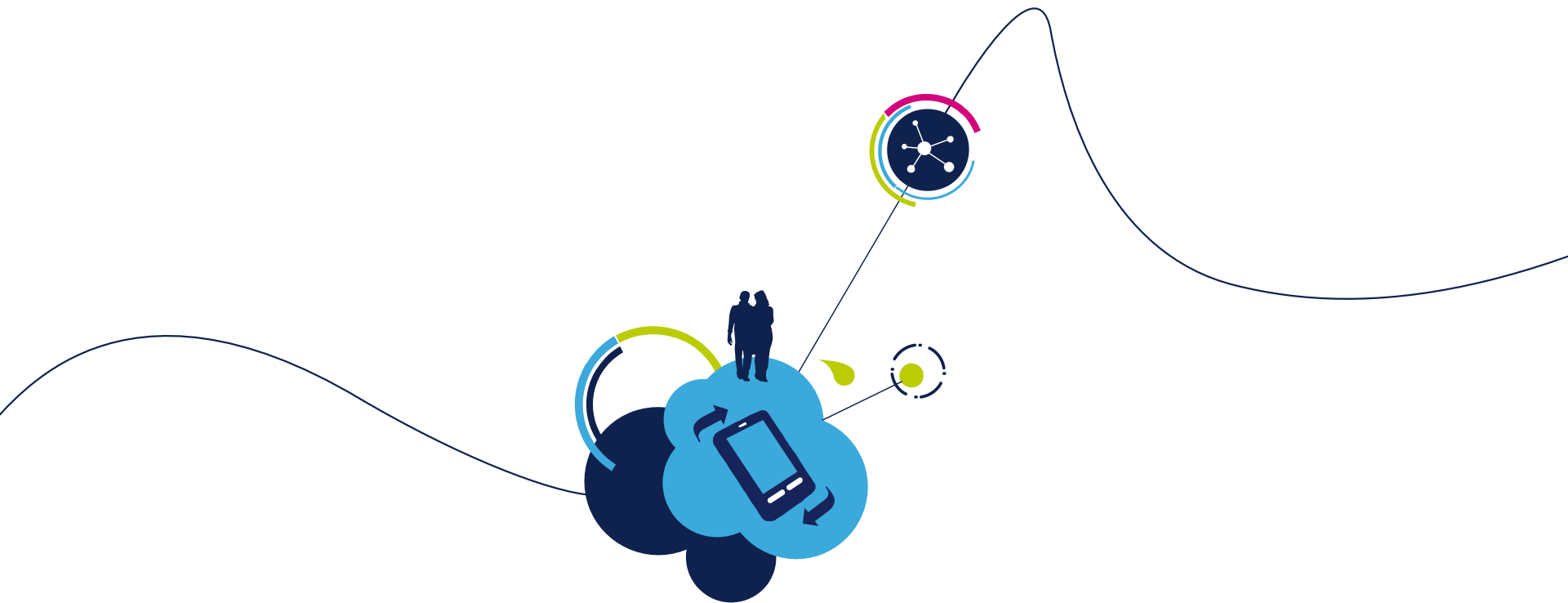


- **Ultra low quiescent current (I_q) (down to 1.4 μA)**
- Very low dropout
- Wide range of miniaturized packages
- Output current from 50 to 150 mA
- Extended input voltage range (up to 24V on ST715)

Main benefits

- Maximize battery life
- Reduce standby power consumption
- Minimized PCB area occupation
- Easy design and implementation





LDOs

Linear Regulators: Cost-effective LDOs

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Max V_{IN}
5.5V

LDK120

- 200 mA, **low dropout**, Noise reduction pin
- Available in SOT23-5L, SC70, **and** DFN6 1.2x1.3 mm

LDKxx:

Low current
(up to 300mA)

Max V_{IN}
5.5V

LDK130

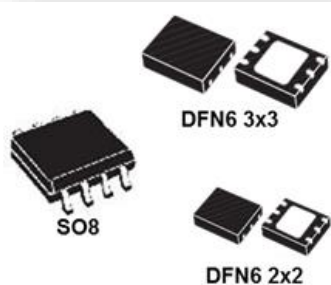
- 300 mA, **low dropout**, Noise reduction pin
- Available in SOT23-5L, SC70, **and** DFN6 1.2x1.3 mm

Max V_{IN}
16V

LDK220

- 200 mA, **low dropout**
- Available in SOT23-5L, SC70, **and** DFN6 1.2x1.3 mm

In development



LDLxx:

Medium current
(1.2 A)

Max V_{IN}
5.5V

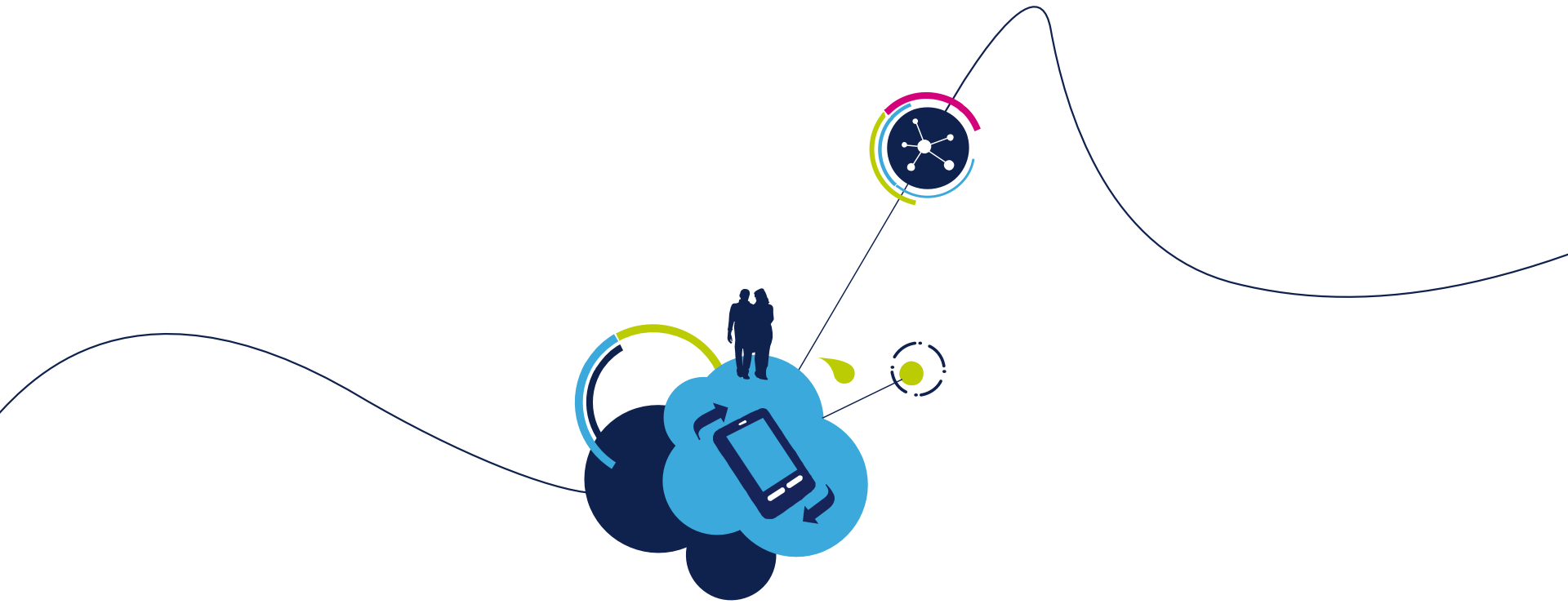
LDL112

- 1.2A, very **low dropout**, Reverse current protection
- Available in SO8, and DFN6 2x2 mm and 3x3 mm

Max V_{IN}
16V

LDL212

- 1.2A, very **low dropout**
- Available in SO8, and DFN6 2x2 mm and 3x3 mm



Power MOSFETs for metering applications

Higher power density, **Best-in-class $R_{DS(on)}$** MDmesh™ K5 series

Widest **Super-Junction MOSFET** Product Portfolio

- 800V, 900V, 950V, 1050V, 1200V, up to 1500V

BEST silicon **performance** in the Market

- Outstanding $R_{DS(on)}$ to optimize **efficiency**

Designed for High Efficiency

- Ultra-low gate charge (Qg) for faster switching
- Low Ciss and Coss for reduced energy losses



PowerFLAT 5*6 HV



D2PAK



TO-247

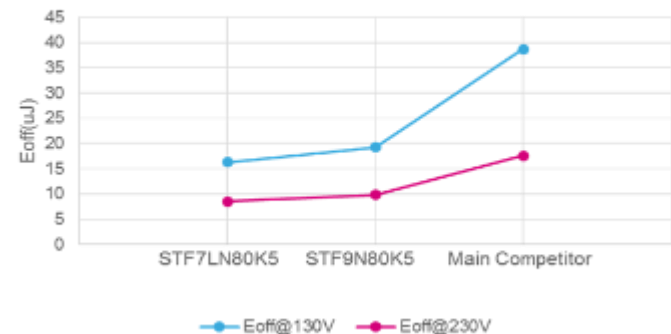


TO-220FP wide Creepage

Efficiency



E_{off}

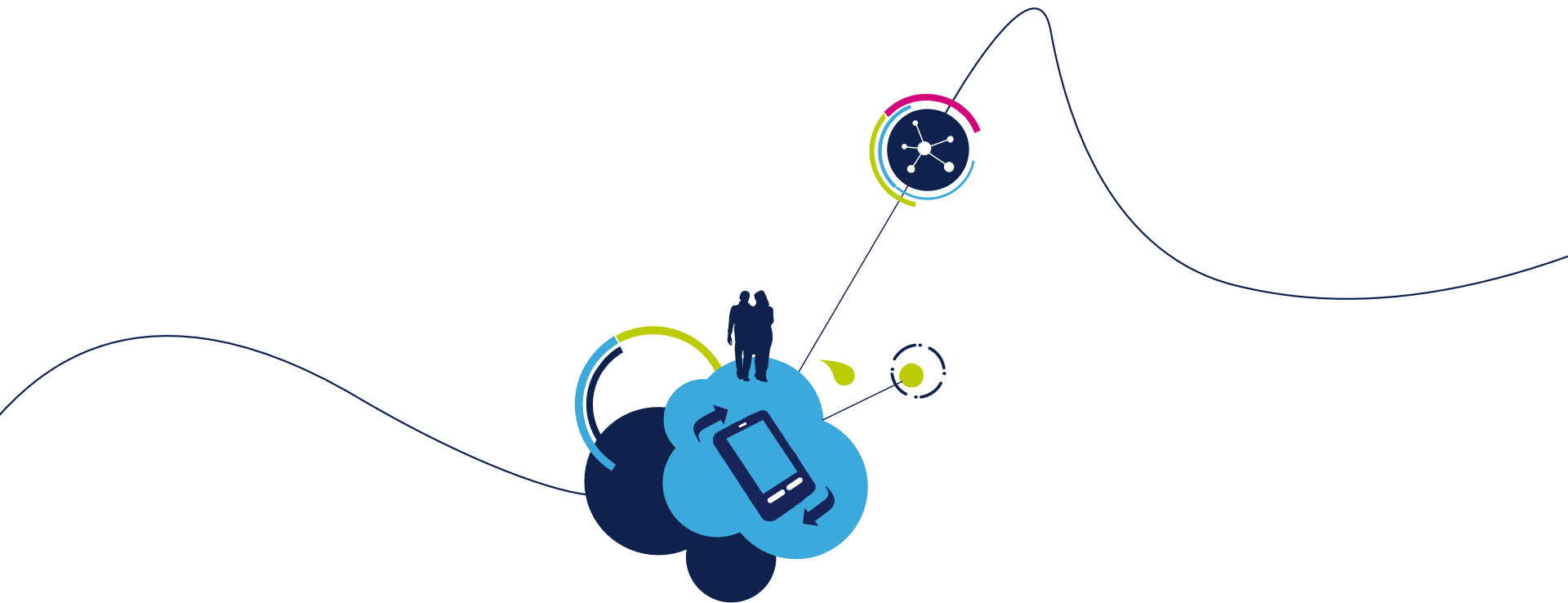


MDmesh™ K5 series selection

SMPS < 75 W

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BV _{DSS} [V]	R _{DS(on)} [Ω]	Max I _D [A]	Sales Type	Packages
800	3.25	2.4	STx3LN80K5	DPAK / IPAK/ TO-220 / FP
	2.6	3	STx4LN80K5	DPAK / IPAK/ TO-220 / FP
	1.75	3.8	STx5N80K5	DPAK / TO-220 / TO-220FP/D2PAK/I2PAK/I2PAKFP
	1.15	5.6	STx7LN80K5	TO-220 / TO-220FP/DPAK, I2PAKFP /IPAK / PowerFLAT 5x6 VHV
	0.90	7.2	STx9N80K5	TO-247 /TO-220 / TO-220FP/I2PAKFP/DPAK/ PowerFLAT 5x6 VHV
	0.610	8.5	STx10LN80K5	TO-220/ TO-220FP/DPAK / I2PAKFP&PowerFLAT 5x6 HV
	0.445	12	STx14N80K5	TO-220FP / D2PAK/I2PAKFP
900	2,1	3	STx4N90K5	DPAK / TO-220 / TO-220FP
	1,10	6	STx6N90K5	DPAK / IPAK/ TO-220 / I2PAK/ TO- 220FP/TO-247
	0,81	7	STx7N90K5	DPAK / TO-220 /FP/TO-247
	0,68	8	STx8N90K5	D2PAK / TO-220 / TO-220FP/TO-247
950	5	2	STx2N95K5	TO-220 / FP / DPAK / IPAK
	2.5	3.5	STx5N95K5	TO-220 / FP / DPAK
	1.25	9	STx6N95K5	TO-220 / FP / DPAK / IPAK / TO-247/ H2PAK
	0.8	8	STx10N95K5	TO-220 / TO-220FP/ TO-247/D2PAK
1050	8	1.5	STx2N105K5	DPAK;IPAK;TO-220;TO-3PF
	3.5	3	STx5N105K5	TO-220 / FP
	2	4	STx7N105K5	TO-247/ TO-220 / FP
	1.3	6	STx10N105K5	TO-220 / TO-220FP/ TO-247
1200	10	1.5	STx1N120K5	TO-220
	2.4	6	STx8N120K5	TO-220 /H2PAK / TO-247



eDesignSuite

eDesignSuite is a **software** platform that helps **developers** select the right product for power conversion and **speeds up** the design-in

AC-DC & DC-DC converters are supported by eDesignSuite

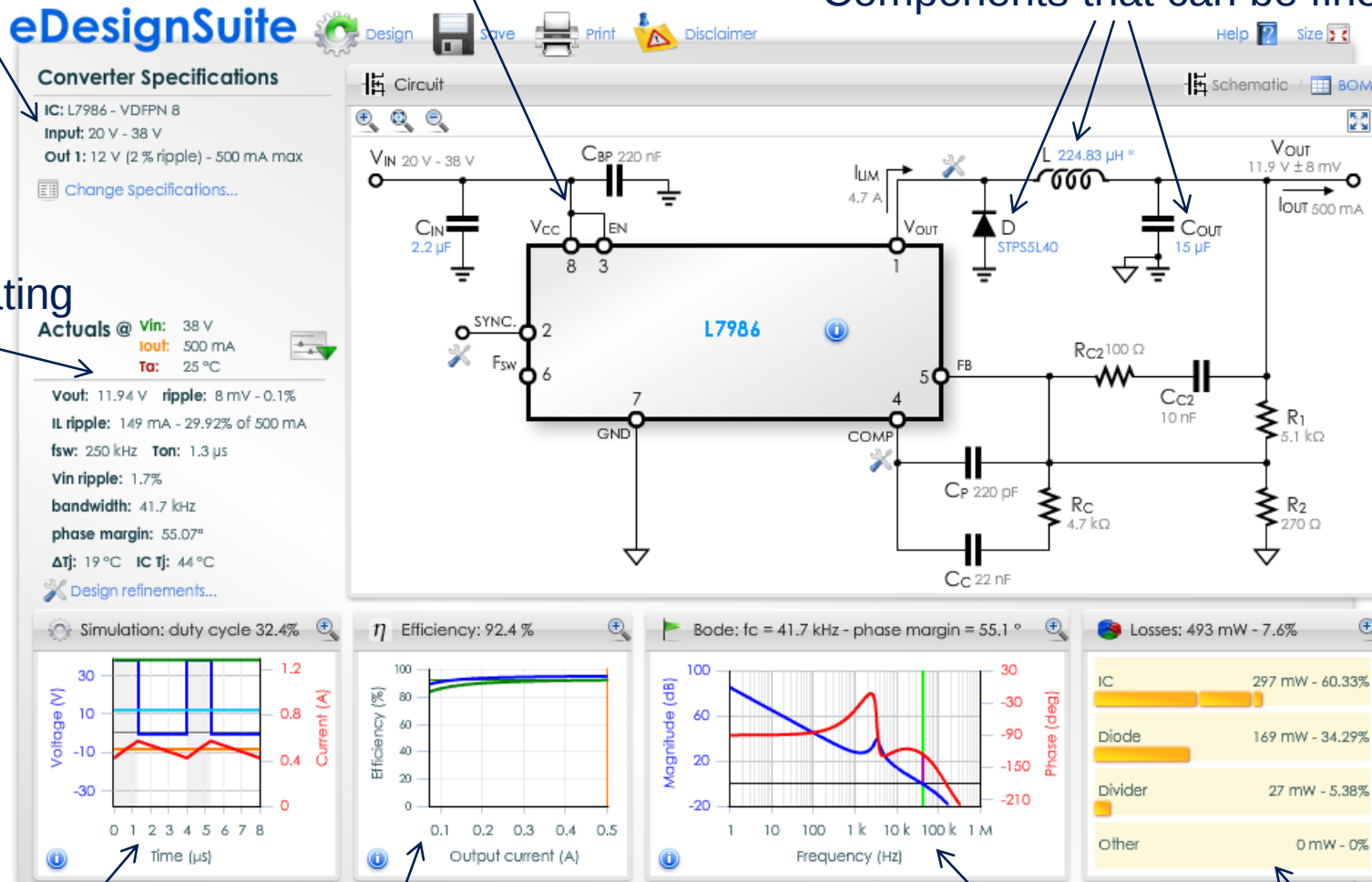
- Go to **my.st.com/analogsimulator**
- Register the first time and log in
- Insert your design specifications
- Get the suitable products
- Choose one, simulate and **purchase**
 - Circuit BOM
 - Electrical waveforms
 - Additional information (stability, efficiency, etc.)

Defined specs

Standard functions

Components that can be fine-tuned

Operating point



Waveforms

Efficiency

Bode plots

Losses split