



Auxiliary SMPS for appliances – CoolSET™

January 2023



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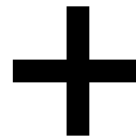
Summary

What is CoolSET?

- › An integrated device with a PWM controller and high voltage MOSFET in a single package
- › To perform AC to DC power conversion – **Switched Mode Power Supply (SMPS)**

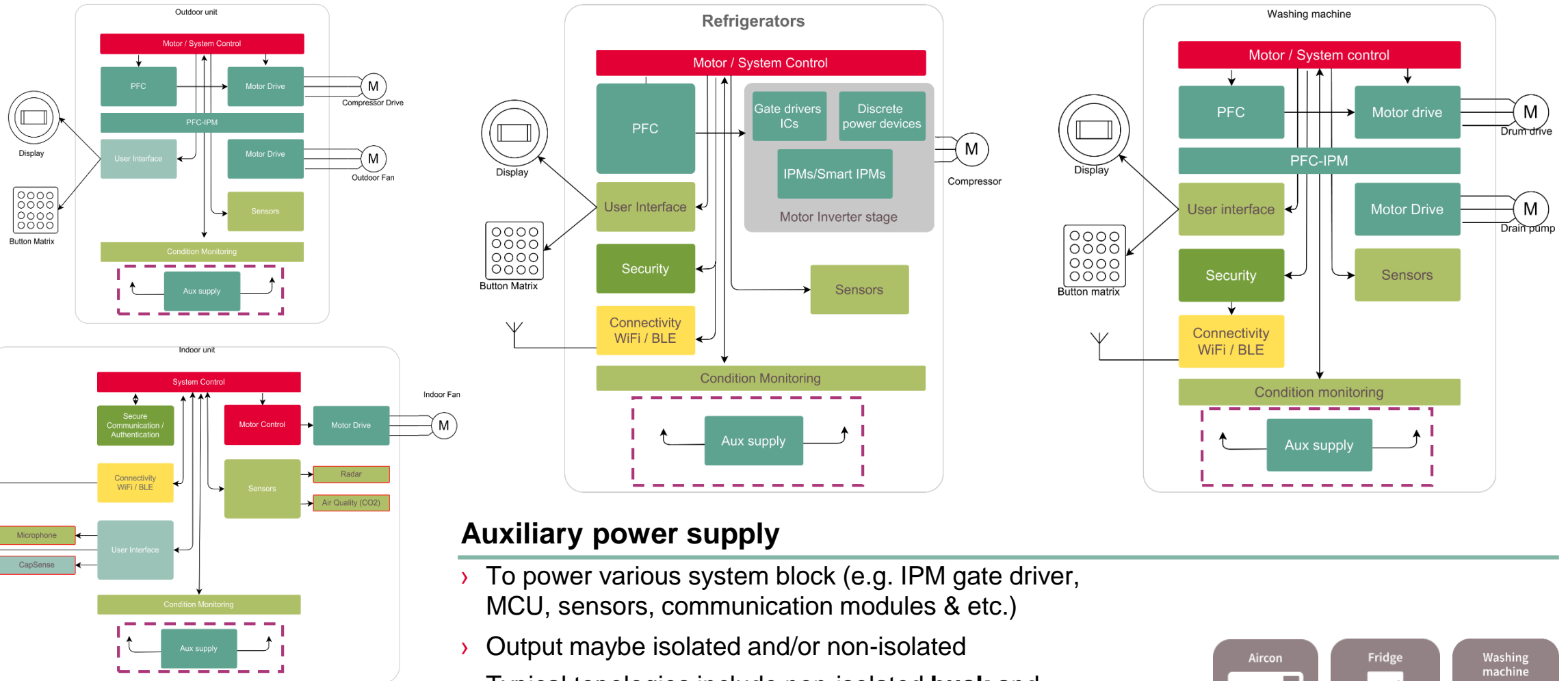


PWM controller



High voltage MOSFET

Typical system building block of major home appliances with auxiliary power supply



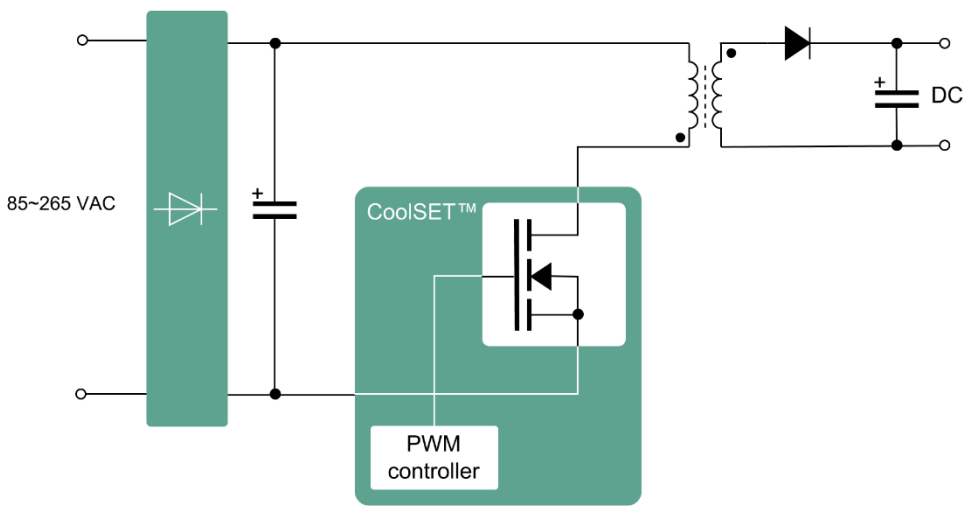
Auxiliary power supply

- > To power various system block (e.g. IPM gate driver, MCU, sensors, communication modules & etc.)
- > Output maybe isolated and/or non-isolated
- > Typical topologies include non-isolated **buck** and isolated/non-isolated **flyback**

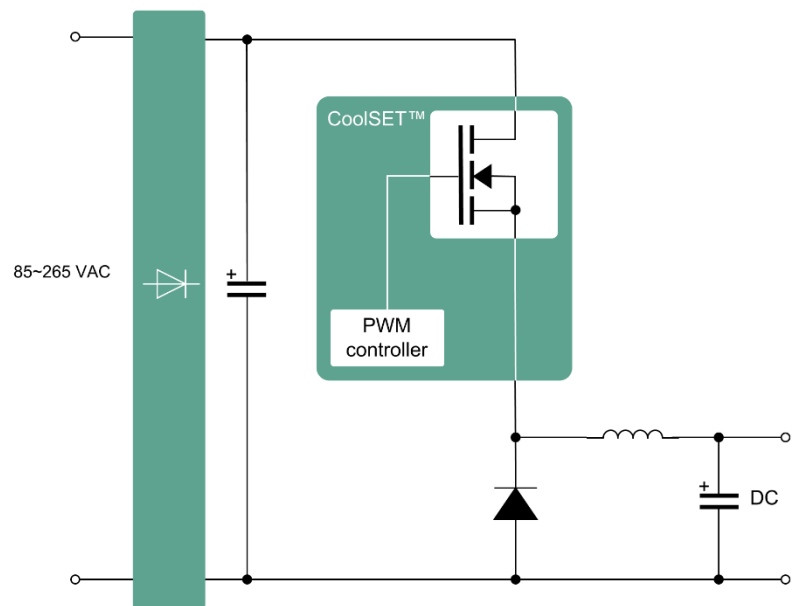


Topologies supported by CoolSET – Flyback and buck

Flyback



Buck



- › Isolated and/or non-isolated
- › Support an output power of up to 44 W
- › Integrated 700 V, 800 V or 950 V MOSFET
- › Switching scheme:
 - Quasi-resonant (valley switching)
 - Fixed frequency @ 65 or 100 or 125 kHz

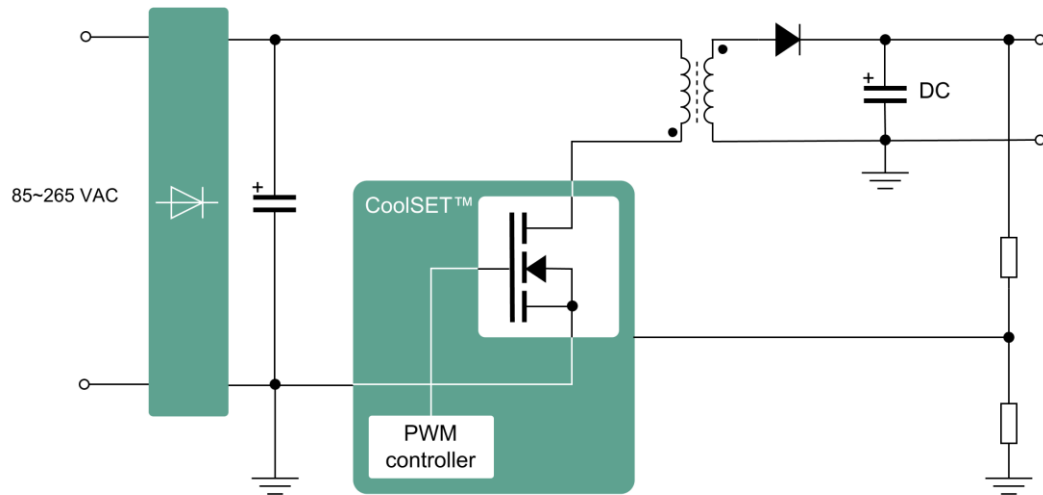
- › Non-isolated
- › Support an output current of up to 700 mA
- › Integrated 800 V or 950 V MOSFET
- › Fixed frequency @ 65 kHz

CoolSET™ Switching Scheme

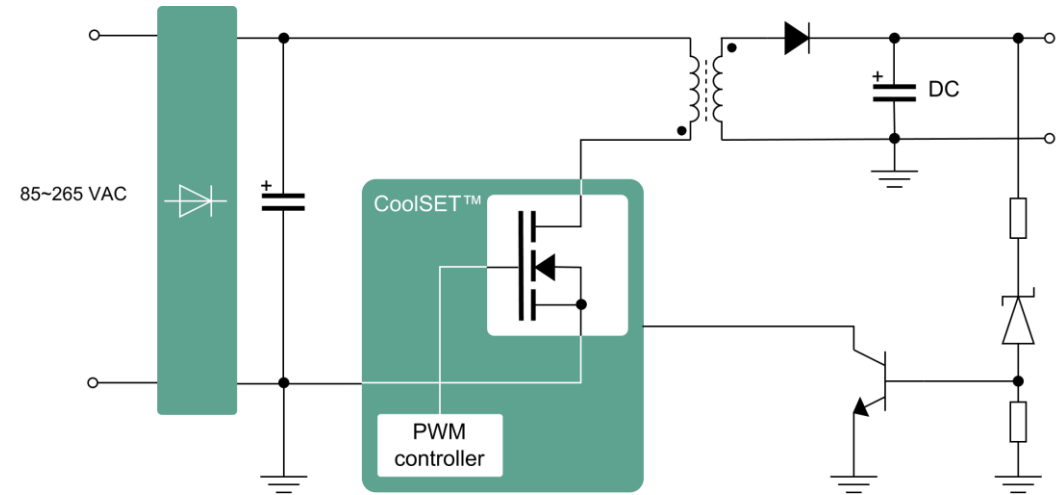
	Quasi-resonant	Fixed frequency
MOSFET turn ON		
	$P_{SW_on} = \frac{1}{2} C_{o(er)} (V_{IN} - V_{reflection})^2 f_{SW}$	$P_{SW_on} = \frac{1}{2} C_{o(er)} (V_{IN} + V_{reflection})^2 f_{SW}$
Frequency	Selectable (based on inductance value)	Fixed frequency @ 65 kHz, 100 kHz or 125 kHz
Operation	DCM	DCM or CCM
Valley Detection	1xR 1xD 1xC	Not applicable

Key feature: BOM savings and ease of design with integrated error amplifier for non-isolated topologies

With integrated error amplifier

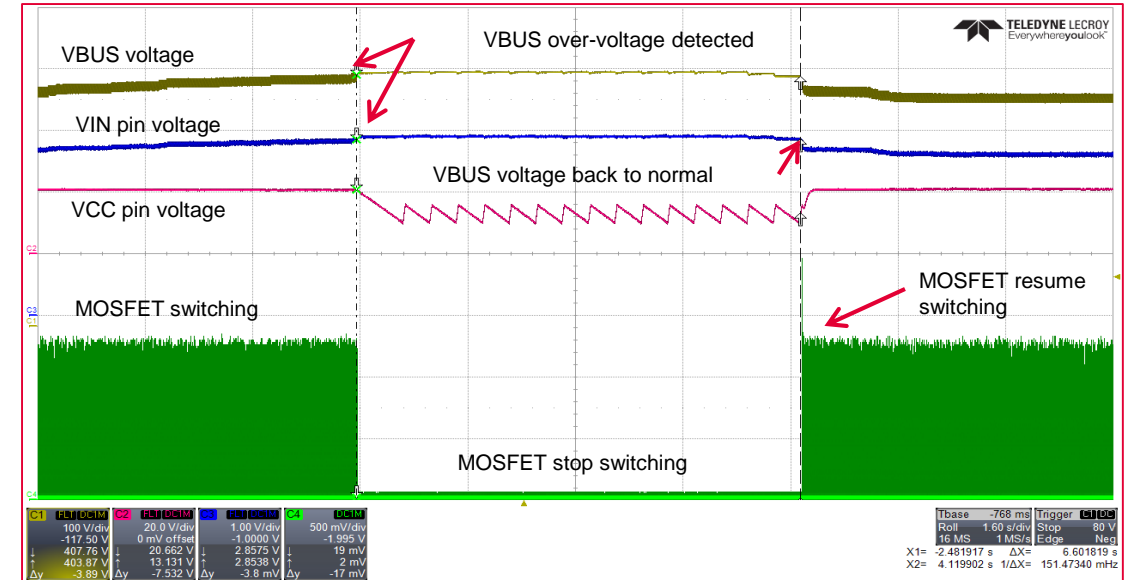
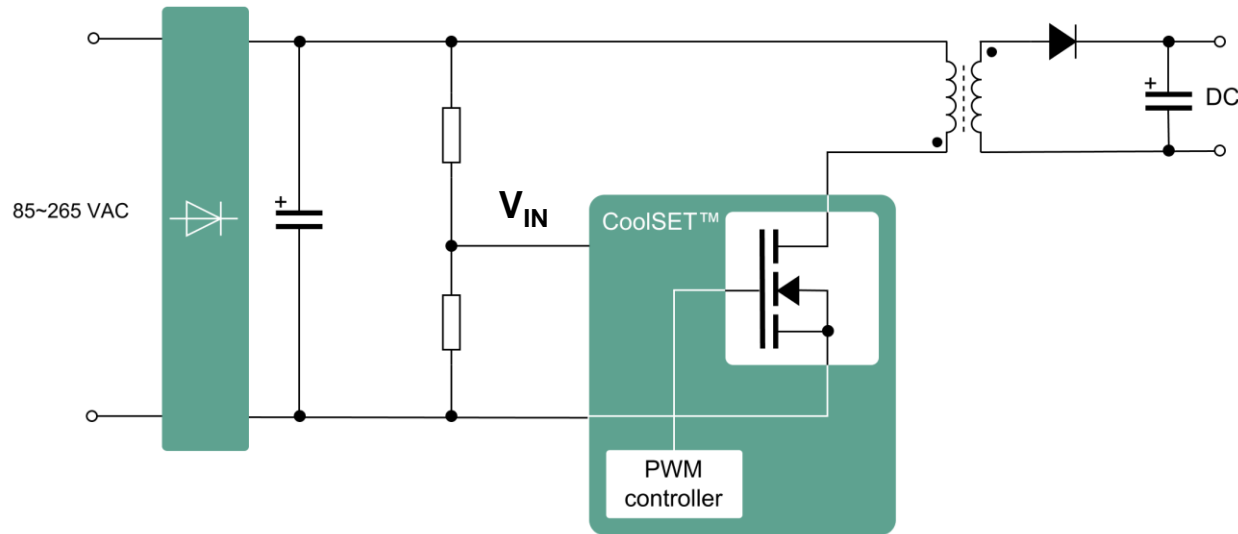


Without integrated error amplifier



- › Ease of design with integrated error amplifier for non-isolated configuration
- › BOM savings (e.g. 1x NPN transistor and 1x Zener diode)
- › Higher and consistent (e.g. across temperature) regulation accuracy

Key feature: Increase system robustness with line over-voltage protection

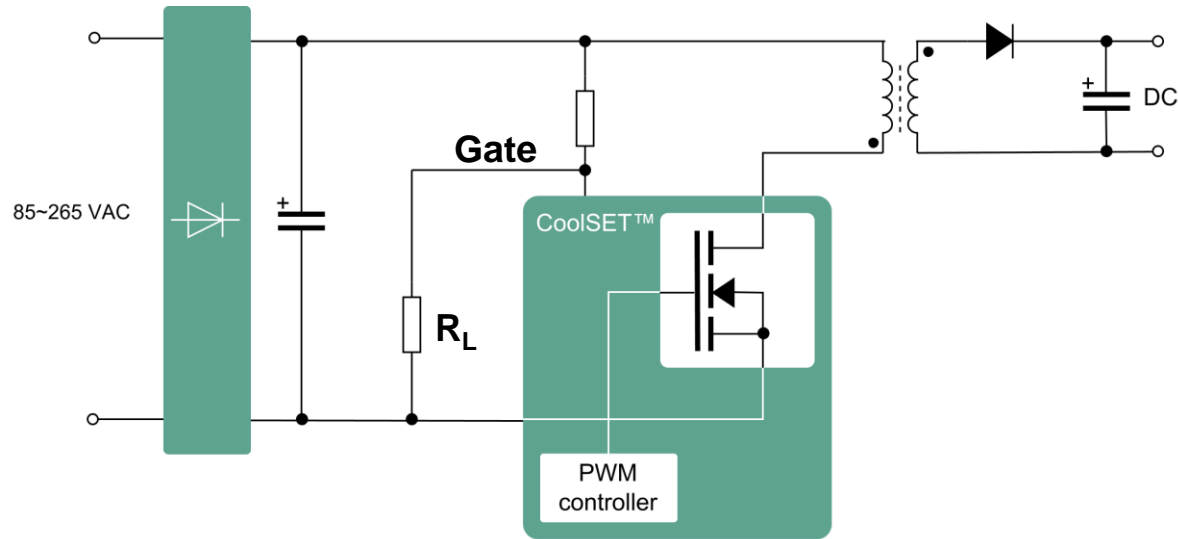


- › A resistor divider network connected to V_{IN} pin to set the protection trigger point
- › Upon exceeding the threshold of V_{IN} pin, after a pre-defined blanking time, protection kicks in
- › Connect to GND to disable line input over voltage protection feature
- › Only available in SMD packages and DIP ICE5xRxxxxCZ variants

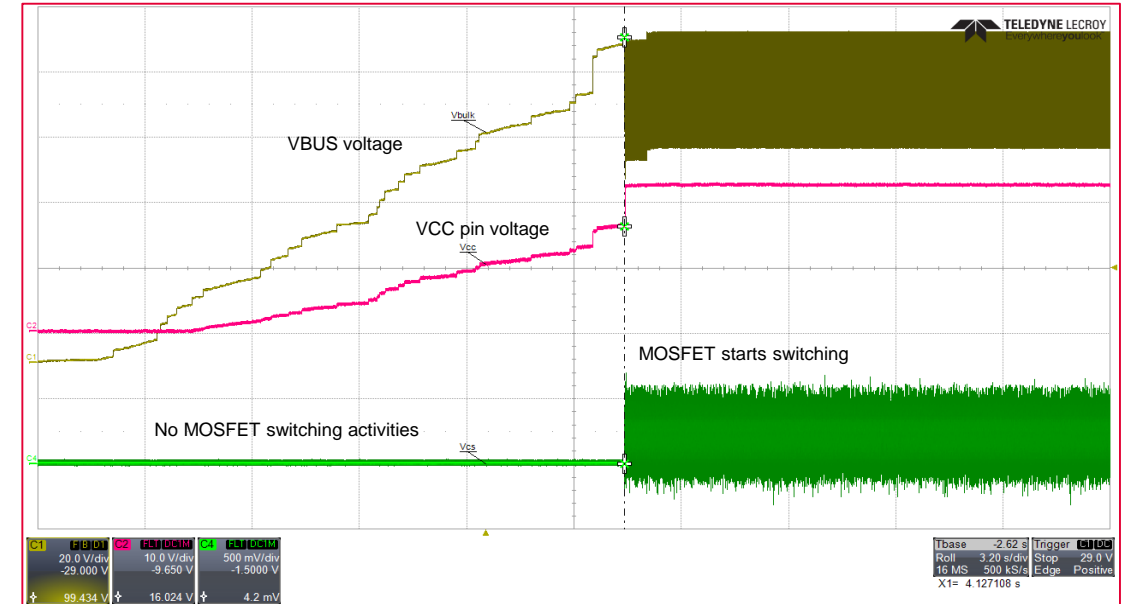
Benefits

- › Directly high voltage BUS with a simple resistor divider
- › Flexibility to set triggering point with resistors
- › Continuous sensing with auto-resume recovery operation

Robust operation with brown in protection

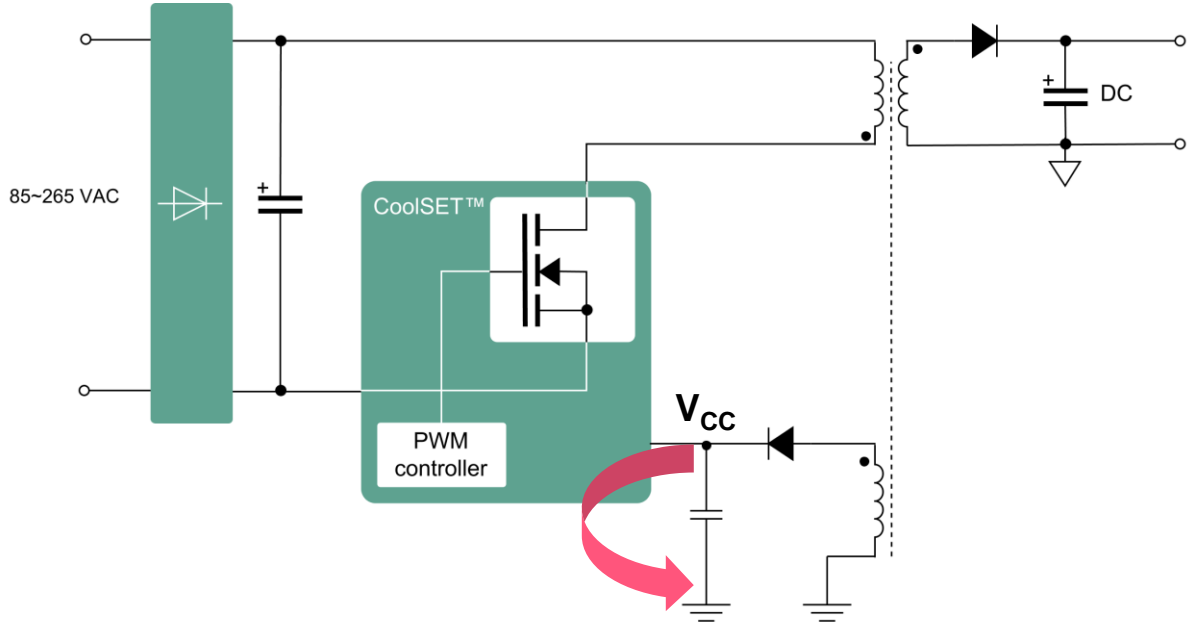


- › A resistor divider network connected to Gate pin to set the protection trigger point
- › In order for CoolSET™ to initiate a start-up, the voltage at Gate pin need to exceed 16 V (typical)
- › R_L is set according to desire input level to avoid undesirable start-up at low input voltage
- › Remove R_L to disable brown-in protection feature



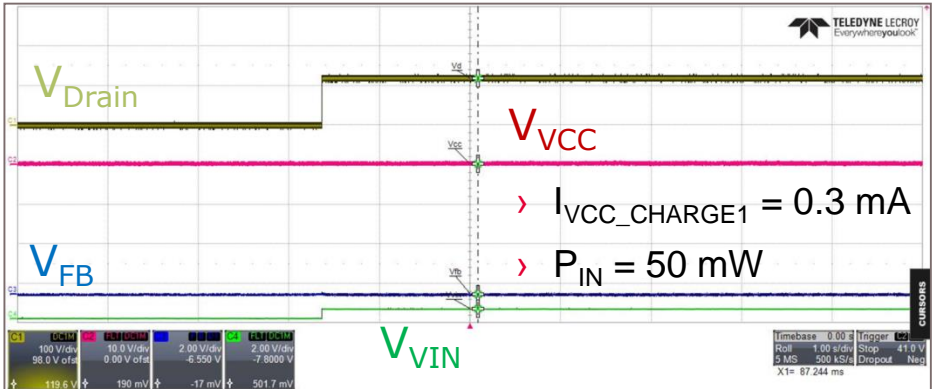
- › VCC pin voltage will rise in proportion to VBUS
- › Once the voltage at VCC pin develop sufficient level to hit VCC_ON, the CoolSET™ will begin to switch

Robust start-up operation with VCC short to GND protection

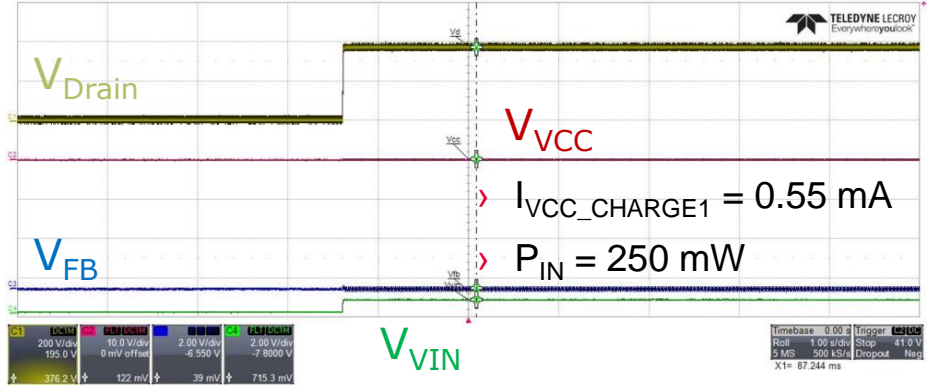


- > Gen5 controller utilize 2 different level of charging current during start-up
- > A low charging current is used to test for abnormality (e.g. pin shorted to ground) whereby VCC voltage could not be built up
- > A higher charging current will be used to accelerate the start-up process in the absence of abnormality
- > **Increase** auxiliary power supply **robustness** against accidental pin short

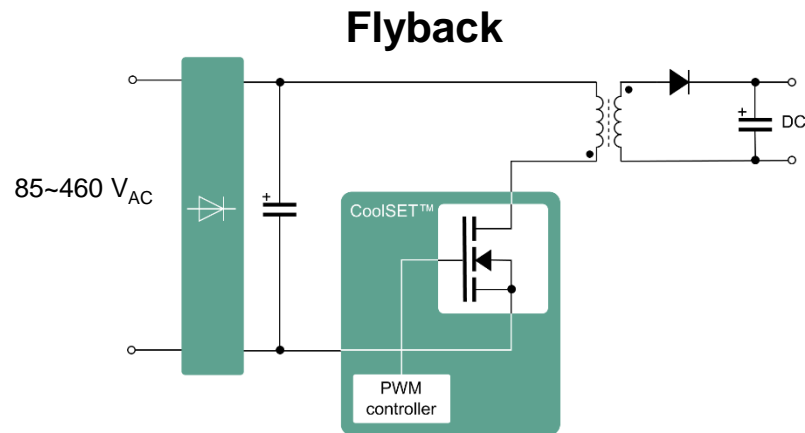
V_{CC} pin short to ground @ 85 V_{AC}



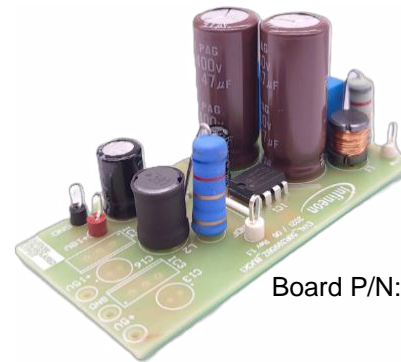
V_{CC} pin short to ground @ 264 V_{AC}



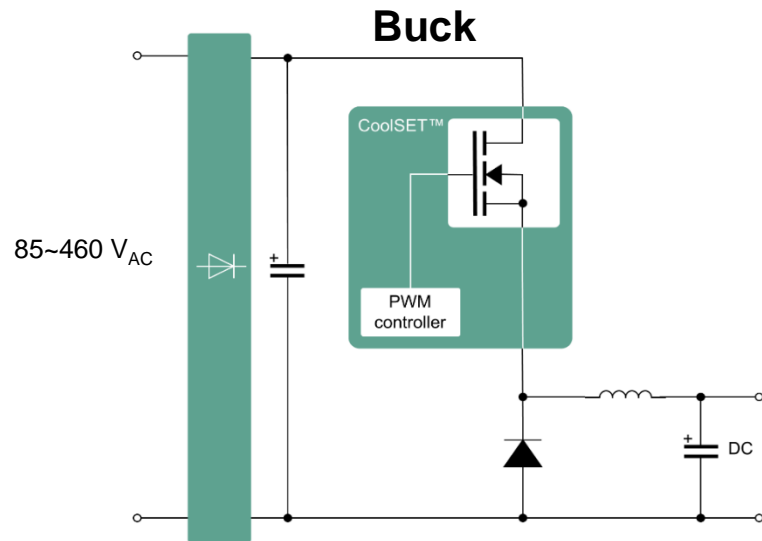
Key feature: Increase system robustness and/or support wide input range with integrated 950 V MOSFET



Board P/N: [REF_5BR3995CZ_16W1](#)



Board P/N: [EVAL_5BR3995BZ_BUCK1](#)



950 V

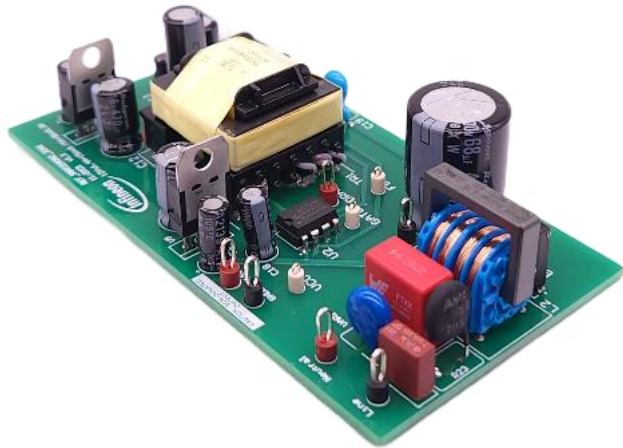
800 V

700 V

Benefits

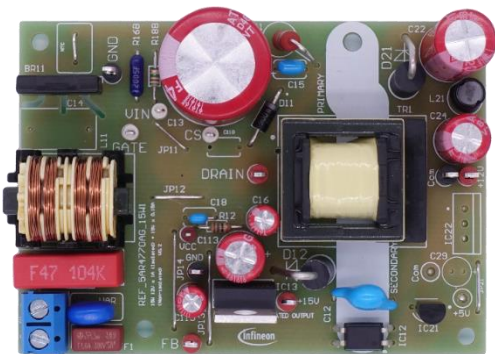
- › Higher design margin with higher MOSFET breakdown voltage
- › Support wide input voltage range (e.g. 460 V_{AC})
- › Increase system design flexibility (e.g. higher reflected voltage)
- › Potential BOM savings with single integrated device and optimization of snubber circuitry

Auxiliary SMPS configuration – Isolated flyback only



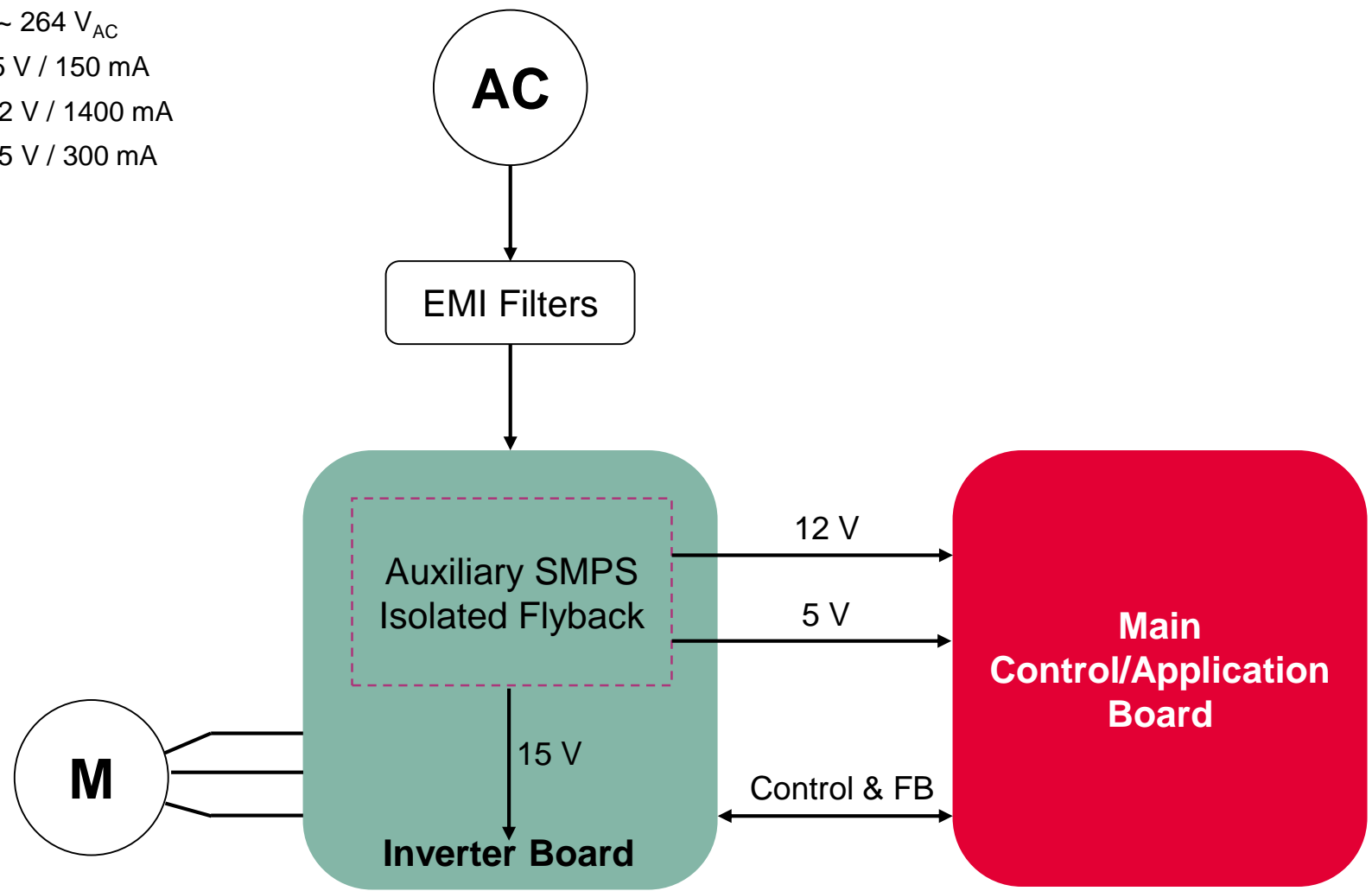
REF 5BR2280BZ 22W1

Input: 85 ~ 264 V_{AC}
 Output #1: 15 V / 150 mA
 Output #2: 12 V / 1400 mA
 Output #3: 5 V / 300 mA



REF 5AR4770AG 15W1

- > 85~264 V_{AC}
- > Non-isolated output: 15 V / 150 mA
- > Isolated output: 12 V / 1 A
- > Isolated output: 5 V (not loaded)



Auxiliary SMPS configuration – Non-isolated buck & isolated flyback



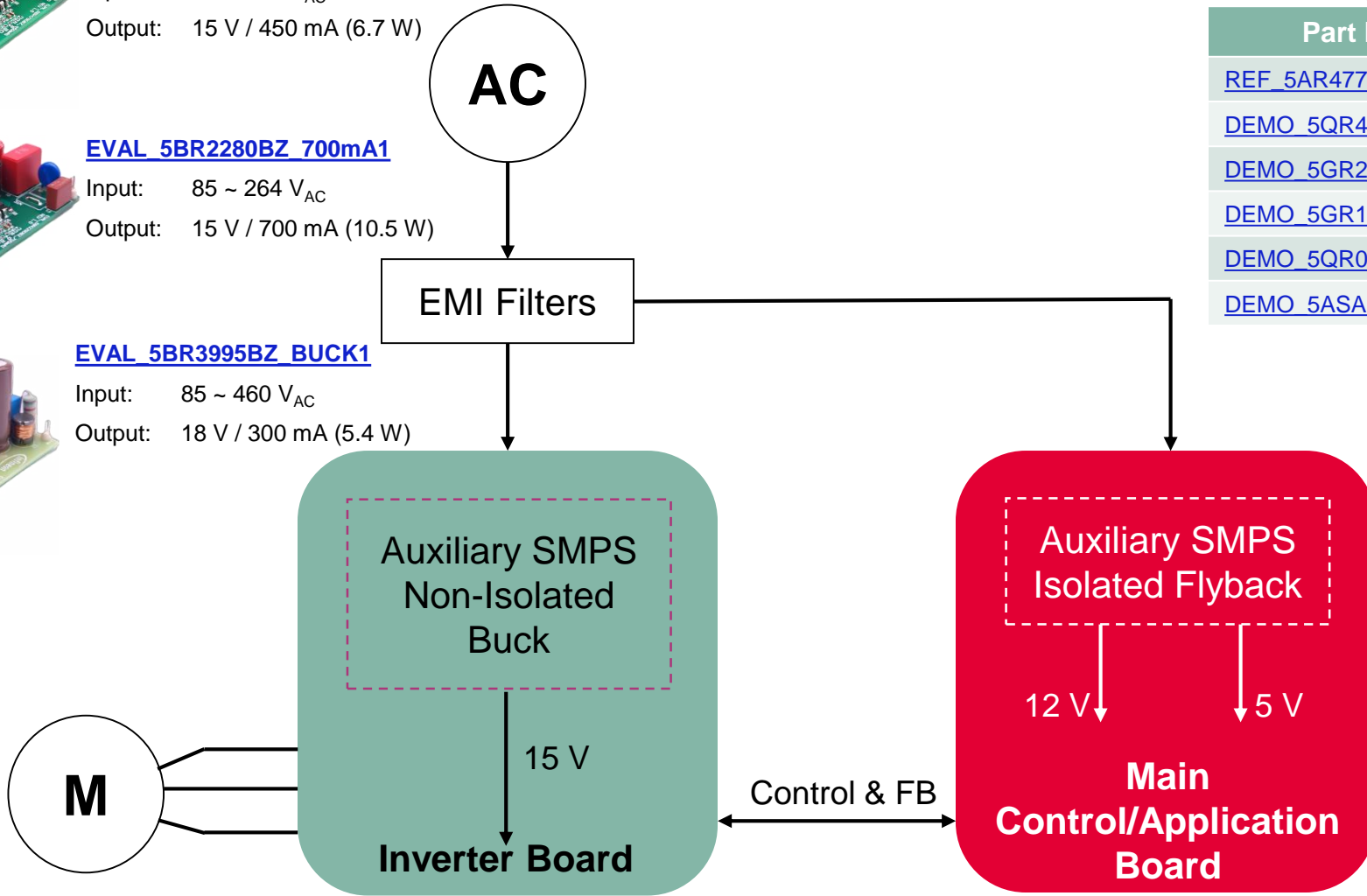
EVAL 5BR4780BZ 450mA1
 Input: 85 ~ 264 V_{AC}
 Output: 15 V / 450 mA (6.7 W)



EVAL 5BR2280BZ 700mA1
 Input: 85 ~ 264 V_{AC}
 Output: 15 V / 700 mA (10.5 W)

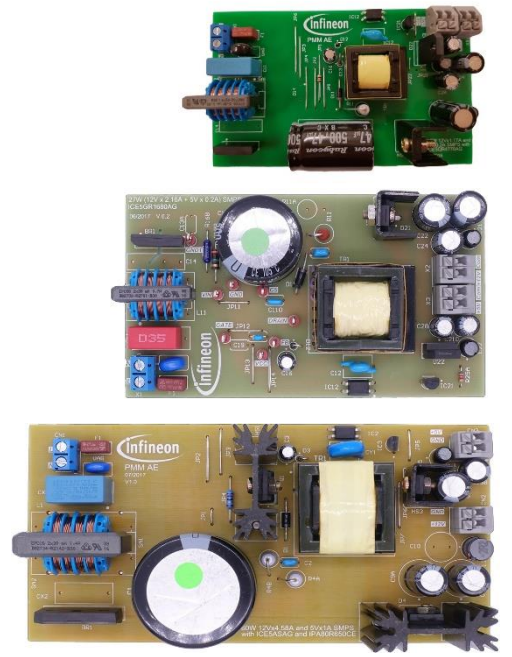


EVAL 5BR3995BZ BUCK1
 Input: 85 ~ 460 V_{AC}
 Output: 18 V / 300 mA (5.4 W)

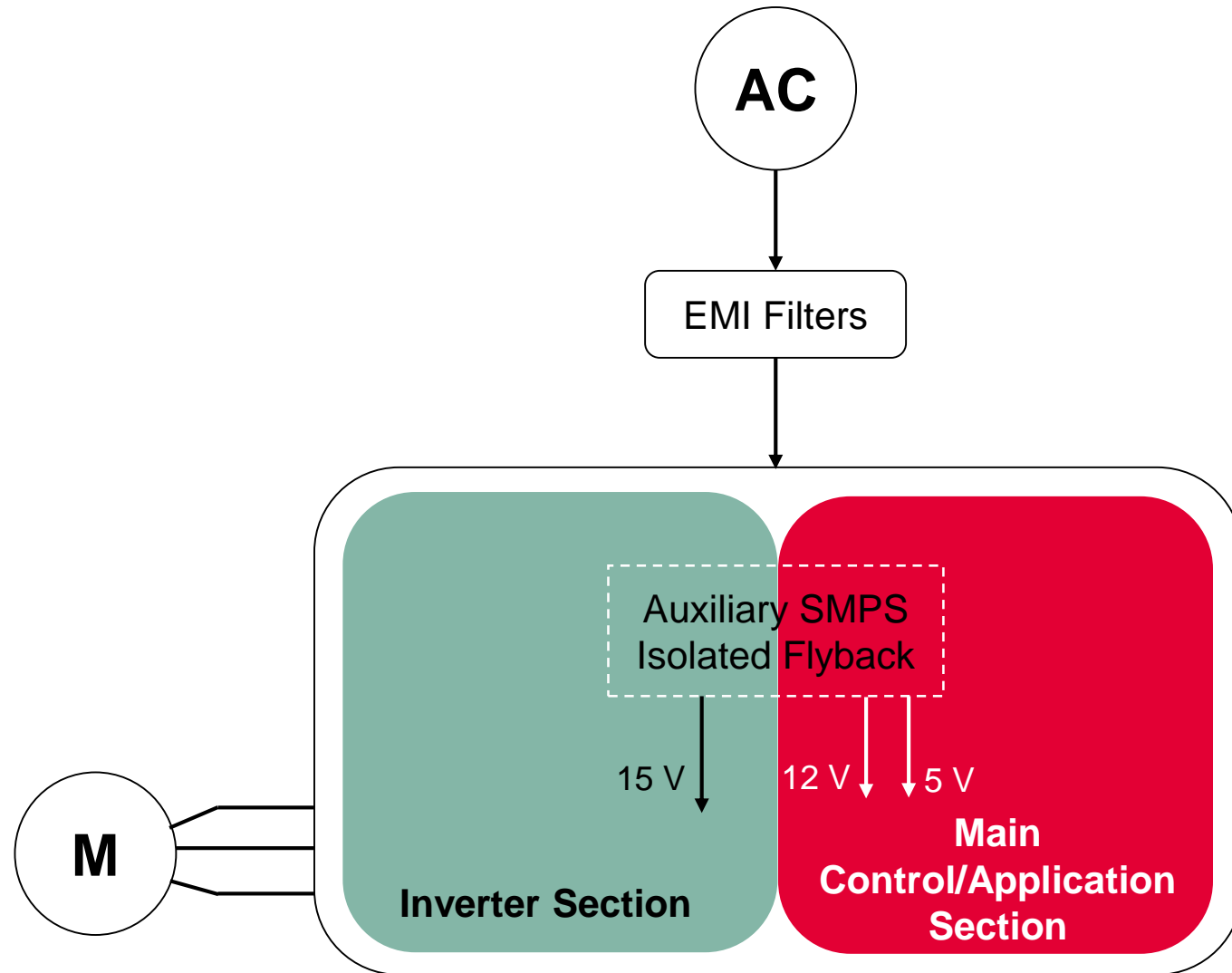


Isolated flyback boards with wide AC input

Part Number	12 V	5 V	P _{OUT}
REF_5AR4770BZS_8W1	0.45 A	0.5 A	8 W
DEMO_5QR4780BG_14W1	1.16 A	0.2 A	15 W
DEMO_5GR2280AG_22W1	1.75 A	0.2 A	22 W
DEMO_5GR1680AG_27W1	2.16 A	0.2 A	27 W
DEMO_5QR0680BG_42W1	3.41 A	0.2 A	42 W
DEMO_5ASAG_60W1	4.58 A	1 A	60 W



Auxiliary SMPS configuration – All in one board



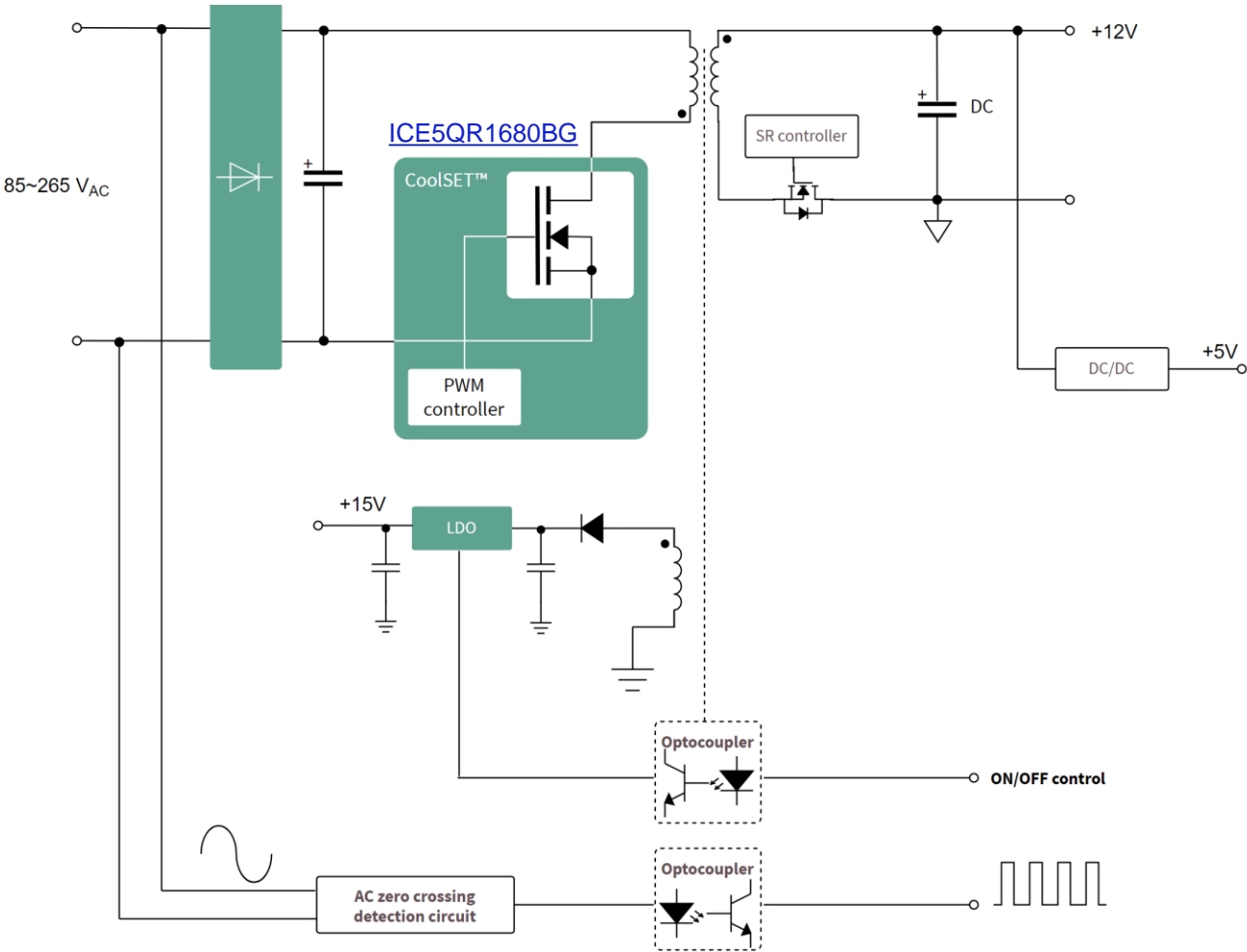
Due to an increase in DC load, auxiliary SMPS output power has increased as well

- › Fan (e.g. evaporator, circulation, condenser & etc.)
- › Display
- › Lighting
- › IoT features

Due to an increase in efficiency requirement:

- › SR (synchronous rectification) is usually implemented for 45 W and above
- › DC-DC on the secondary side
- › LDO @ primary side ON/OFF control via secondary side

High performance 30 W SMPS reference design



Board P/N: [REF_5QR1680BG_30W1](#)

Key Features

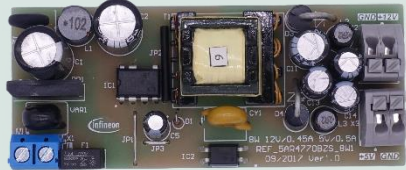
- > Compact form factor (q243): 109 x 53 x 36 mm
- > Wide range input: 85~264 V_{AC}
- > Output: 12 V/2.2 A, 5 V/0.2 A and 15 V/0.15 A (non-isolated)
- > Robust line input protection with over-voltage and Brown IN/OUT protection
- > High efficiency > 89%
- > MCU (not included on board) control via secondary:
 - LDO ON/OFF
 - AC zero crossing detection signal

Infineon 5th generation CoolSET™

Auxiliary power supply evaluation boards for aircon application

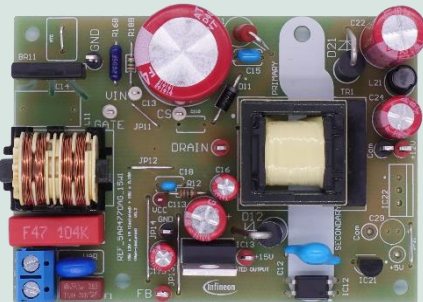


Indoor RAC (isolated except 15 V rail)



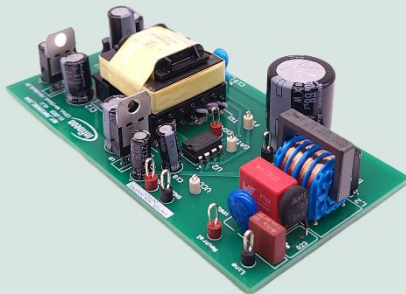
REF 5AR4770BZS 8W1

Input: 85 ~ 265 V_{AC}
 Output #1: 12 V / 450 mA
 Output #2: 5 V / 500 mA
 Pout: 8 W



REF 5AR4770AG 15W1

Input: 85 ~ 264 V_{AC}
 Output #1: 15 V / 150 mA
 Output #2: 12 V / 1000 mA
 Pout: 15 W



REF 5BR2280BZ 22W1

Input: 85 ~ 264 V_{AC}
 Output #1: 15 V / 150 mA
 Output #2: 12 V / 1400 mA
 Output #3: 5 V / 300 mA
 Pout: 22 W

Outdoor RAC (non-isolated)



REF 5AR4770AG 13W1

Input: 85 ~ 264 V_{AC}
 Output #1: 15 V / 150 mA
 Output #2: 12 V / 850 mA
 Pout: 13 W



REF 5BR4780BZ 15W1

Input: 85 ~ 264 V_{AC}
 Output #1: 15 V / 150 mA
 Output #2: 12 V / 800 mA
 Output #3: 5 V / 300 mA
 Pout: 15 W



REF 5BR3995BZ 16W1

Input: 85 ~ 264 V_{AC}
 Output #1: 15 V / 150 mA
 Output #2: 12 V / 900 mA
 Output #3: 5 V / 300 mA
 Pout: 16 W

Misc (non-isolated buck)



EVAL 5BR4780BZ 450mA1

Input: 85 ~ 264 V_{AC}
 Output: 15 V / 450 mA (6.7 W)



EVAL 5BR2280BZ 700mA1

Input: 85 ~ 264 V_{AC}
 Output: 15 V / 700 mA (10.5 W)



EVAL 5BR3995BZ BUCK1

Input: 85 ~ 460 V_{AC}
 Output: 18 V / 300 mA (5.4 W)

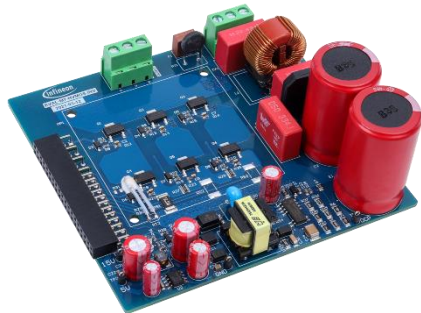
Inverter solutions with CoolSET™ on board



200 W inverter evaluation board (example: fridge)

[EVAL-M7-HVIGBT-INV](#)

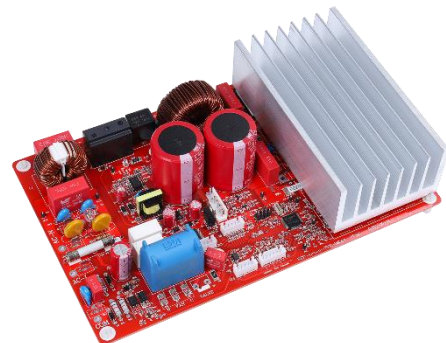
- › IGBT → IKD04N60RC2
- › LDO → IFX54441EJV50
- › Auxiliary power supply → CoolSET™ → [ICE5GR4780AG](#)



300 W inverter evaluation board (example: fridge)

[EVAL-M7-HVMOS-INV](#)

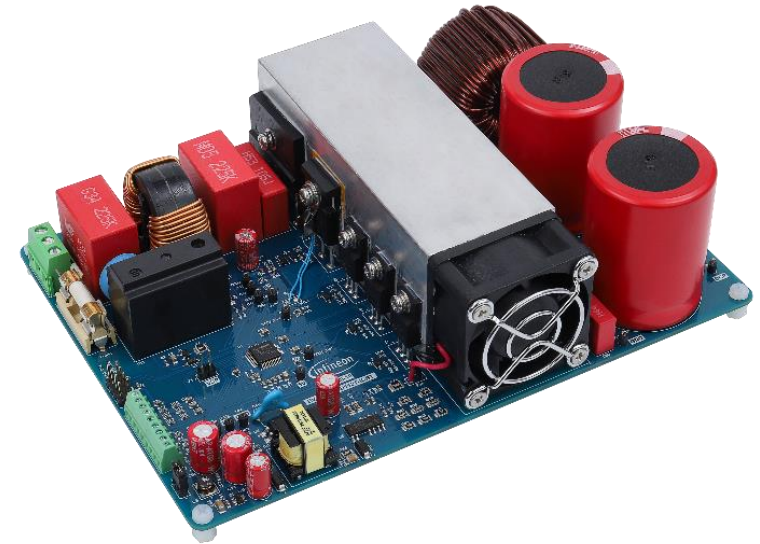
- › MOSFET → IPN60R600PFD7S
- › LDO → IFX54441EJV50
- › Auxiliary power supply → CoolSET™ → [ICE5GR4780AG](#)



RAC ODU reference design

[REF-AIRCON-C302A-IM564](#)

- › iMotion™ motor control IC → IMC302A-F064
- › IPM → CIPOS Mini IPM → IM564-X6D
- › Gate driver → 1ED44175
- › Auxiliary power supply → CoolSET™ → [ICE5AR4770BZS](#)



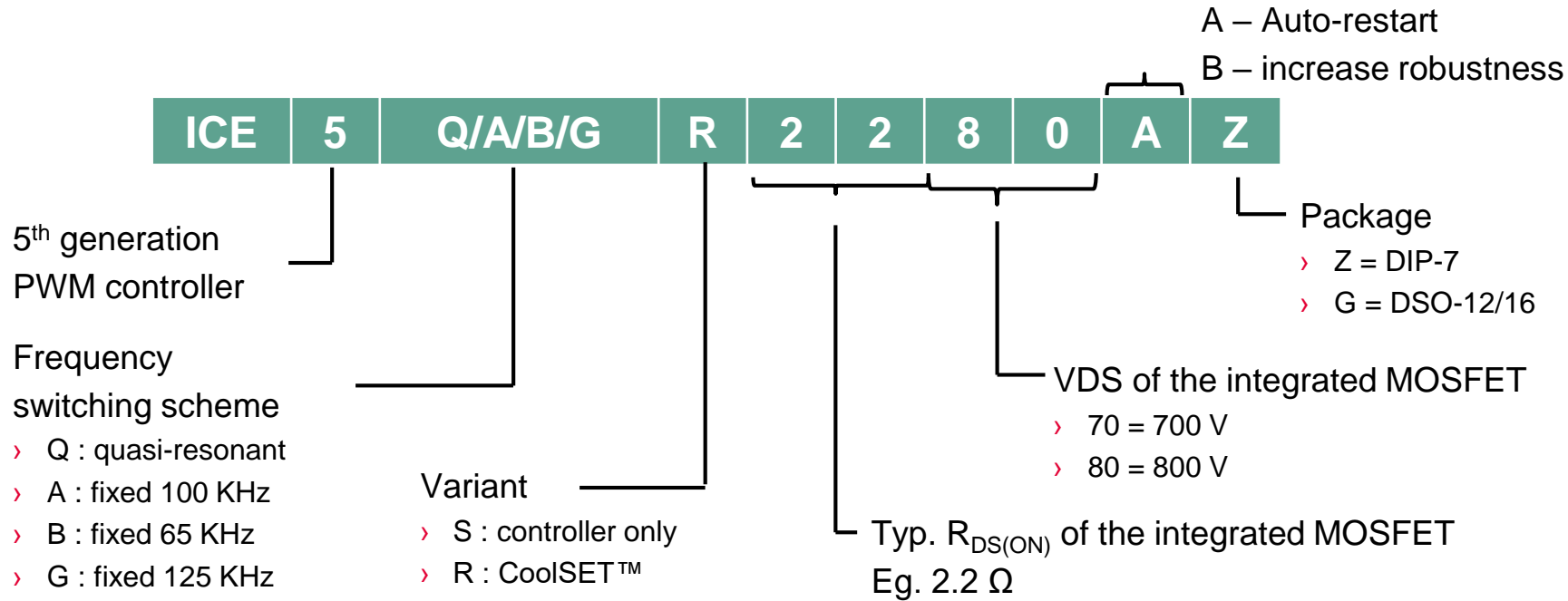
1.2 KW PFC and inverter evaluation board

[EVAL-IKA15N65ET6](#)

- › iMotion™ motor control IC → IMD112T-6F040
- › Diode → IDW30E65D1
- › IGBT → IKWH30N65WR6 and IKA15N65ET6
- › LDO → TLS202B1MBV33
- › Current sensor → TLI4971
- › Gate driver → 1ED44175N01B
- › Power MOSFET → IRLML2030TRPbF
- › Auxiliary power supply → CoolSET™ → [ICE5GR4780AG](#)

5th generation Quasi-resonant portfolio

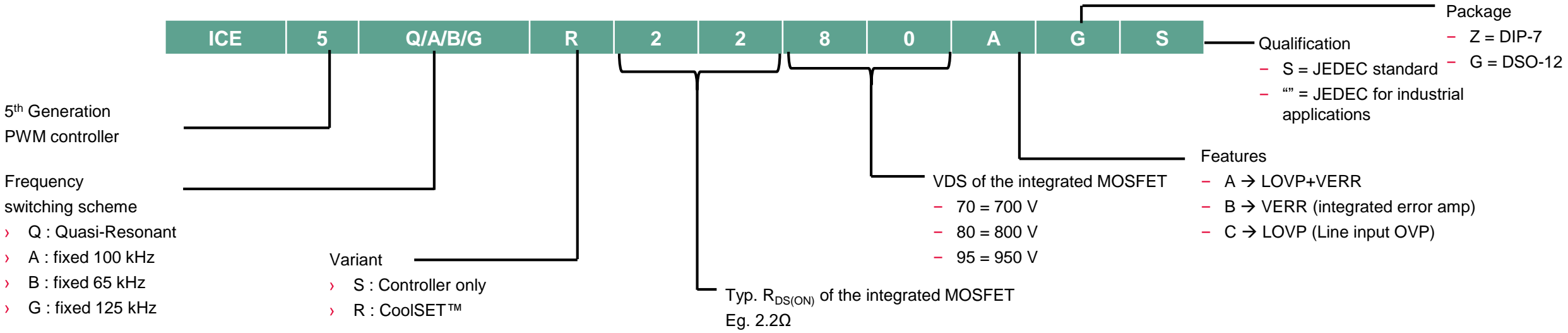
Max Pout 85~300 V _{AC} Ta=50°C	15 W	22 W	27 W	41-42 W	60 W
DSO-8					ICE5QSBG
DSO-12	ICE5QR4780BG	ICE5QR2280BG	ICE5QR1680BG	ICE5QR0680BG	



Not for new design

5th generation: Fixed frequency flyback controllers and integrated power stages

Max P _{out} 85~300 V _{AC} T _a =50°C		15 W	17 W	23 W	27 W	40 W	60 W
External	DSO-8						ICE5ASAG ICE5GSAG
700 V	DIP-7	ICE5AR4770BZS					
	DSO-12	ICE5AR4770AG					
800 V	DIP-7	ICE5AR4780BZS ICE5BR4780BZ		ICE5AR2280CZ ICE5BR2280BZ		ICE5AR0680BZS	
	DSO-12	ICE5GR4780AG		ICE5GR2280AG	ICE5GR1680AG	ICE5AR0680AG	
950 V	DIP-7		ICE5AR3995BZ ICE5BR3995BZ ICE5BR3995CZ				



Summary

Why Infineon?

- › Not only supports power scaling but MOSFET breakdown voltage (700 V, **800 V** & **950 V**) as well
 - Able to easily increase system robustness or design margin with minimal changes for a **pin-2-pin (DIP-7 package) platform**

- › Mature **PWM concept** and ability to **disable** light-load control to **minimize and/or eliminate audible noise**
 - For example, no standby control necessary with outdoor unit

- › Wide selection of **auxiliary power supply evaluation boards** covering both indoor and outdoor aircon applications to shorten time to market

- › Wide selection of switching frequency (65 kHz, 100 kHz and 125 kHz) to increase the possibility of **re-using** key components such as power **transformers** and/or inductors

- › Infineon is a **one-STOP shop** to serve your [Home Appliances](#) needs beyond auxiliary power supply such as IPM, IGBTs, sensors, MCU and much more.

For more information, please visit www.infineon.com/CoolSET and queries via community.infineon.com