



ST motor control solutions for high-power thermal management HVAC, BESS, AI data centers

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STMicroelectronics

High-power thermal management systems



Commercial aircon



Heat pumps



Heating electrification



Grid stability



ESS thermal control



HPC liquid cooling



AI data centers

2024-2035 electricity demand growth projections

Cooling accounts for an average 40%* of total data center electricity bills

Space cooling (HVAC)

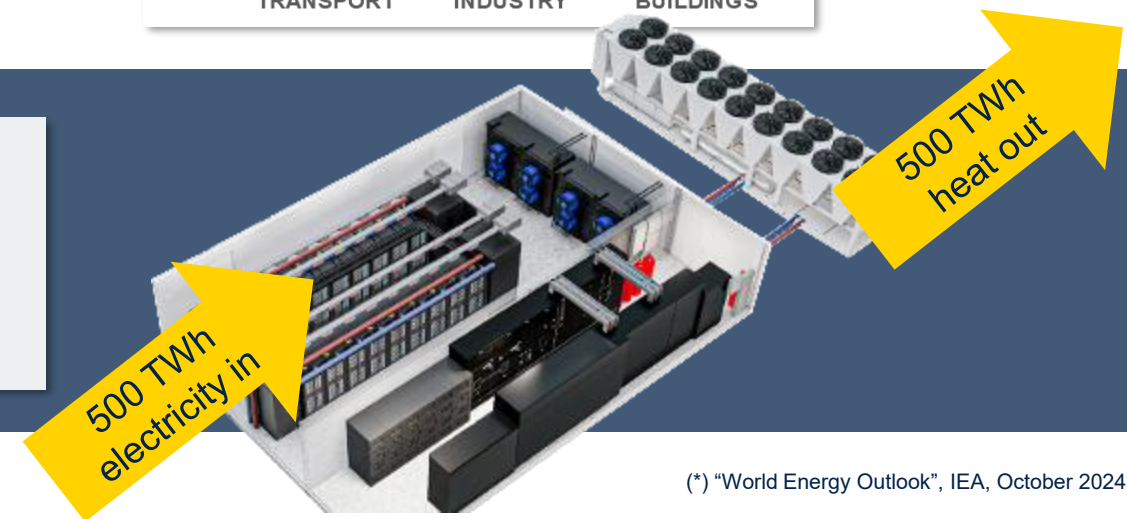
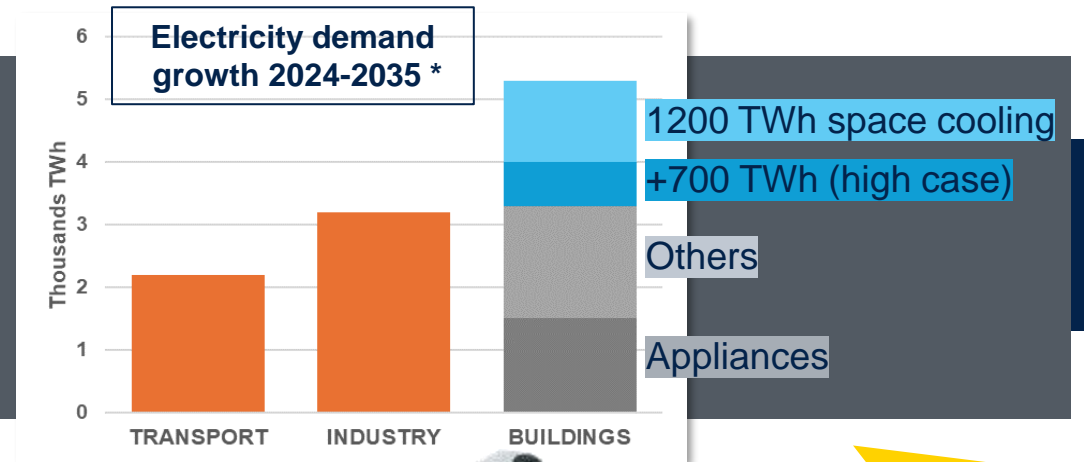


Increasing global temperatures and rising incomes.
Demand growth 1,200 TWh*
→20% of global growth

AI datacenters



Increasing global temperatures and rising incomes.
Demand growth 1,200 TWh*
→20% of global growth



Electricity demand growth the key role of thermal management systems

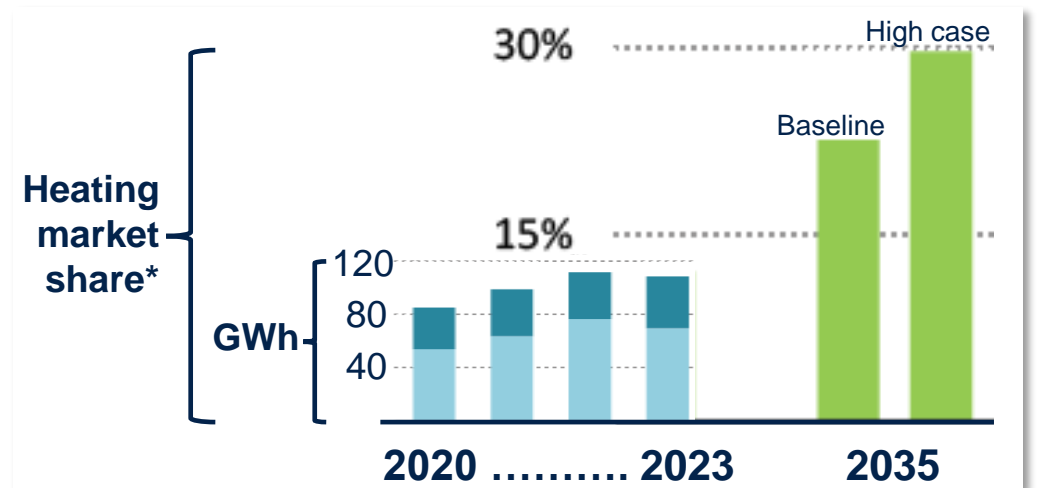
Heat pumps: energy efficiency and electrification of heating
Demand growth 380 TWh* → 5.5% of global growth

Cooling systems (HVAC): +20% of global growth to 2035

AI data centers: +10% (up to)

Heat pumps: +5.5%

= +35.5% of global electricity growth in
high-power thermal management systems



Motor control requirements in high-power thermal management



Chillers, compressors



EC fans



Water pumps



NANOEDGE AI
STUDIO



Energy efficiency

24/7-on applications

Consuming 35% of electricity growth

Reliability & performance

Cooling continuity is a **must**

Temperature to be strictly maintained

Integration

For reliability and modularity

High space constraints

Energy efficiency in AI data centers

Efficiency is all about cooling systems!

Sections efficiency

Type	Transformer	UPS	Cooling	Lighting	Total efficiency	PUE
Enterprises <500 kW	97.5%	-	53.5%	99%	50%	2
HPC <5 MW	98.2%	94%	67.6%	99%	58.8%	1.7
Hyperscale 1-150 MW	98.3%	95%	86.7%	99%	83.3%	1.2



How can motor control improve efficiency?

Motor variable speed drives (vsd foc):

adjust motor speed in accordance with current needs, as computational load is not constant during the day;

Power quality, distributed dPFC:

reduce losses due to harmonics (and cost of filters, generators, cables)

Power conversion efficiency in inverters & converters:

Silicon carbide, superjunction MOSFET, gallium nitride:

Example: 5 MW data center, PUE = 1.7

Electricity cost saving ~100k\$ per year



Reliability in AI data centers and BESS systems

GOAL: 0 failure objective*. A failure could cost tens of k\$ to M\$

Ensuring the availability of critical infrastructures
 Reduction of downtimes due to servicing
 Maximum reliability through effective monitoring

Compressors



EC fans



Water pumps




Targets	Solutions
Resilience vs high temperatures overcurrent, overvoltage, etc	ST SiC, STGAP
Reduce mechanical stresses on piping avoid water leakage	STM32 FOC SDK Soft Start
EMC, equipment reliability	dPFC, power quality Minimize iTHD
Equipment redundancy ensure cooling continuity	6phase Fault Tolerant FOC
Fan bearing monitoring	ST MEMS, Nano Edge AI predictive maintenance
Fail Safe under communication loss	STM32 Edge intelligence



Integration example in A2W heat pumps

10 ~ 15 kW
3-ph Vienna PFC
+
BLDC FOC



5-15 kW
3 ph ~ 380 V



Outdoor unit

PFC converter

BLDC compressor inverter



Air
heat
source

2x BLDC
outdoor fan
inverter

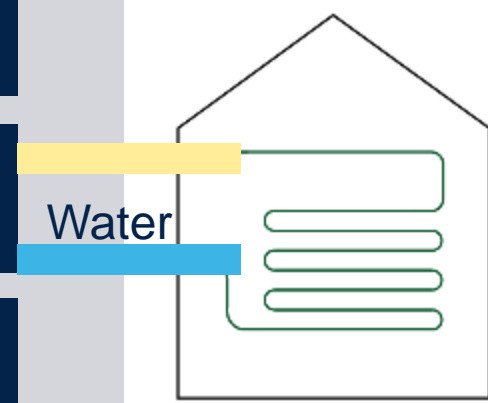
Indoor unit

Connectivity

2x BLDC pump inverter

Main control & HMI


15-45 kW
COP ~ 3





Integration example in A2W heat pumps

3 ~ 7 kW
1-phase PFC
+
3x BLDC FOC



3 - 7 kW
1ph ~ 230 V



Outdoor unit

PFC
converter

BLDC
compressor
inverter

2x BLDC
outdoor fan
inverter

Air
heat
source



Indoor unit

Connectivity

2x BLDC pump
inverter

Main control
& HMI

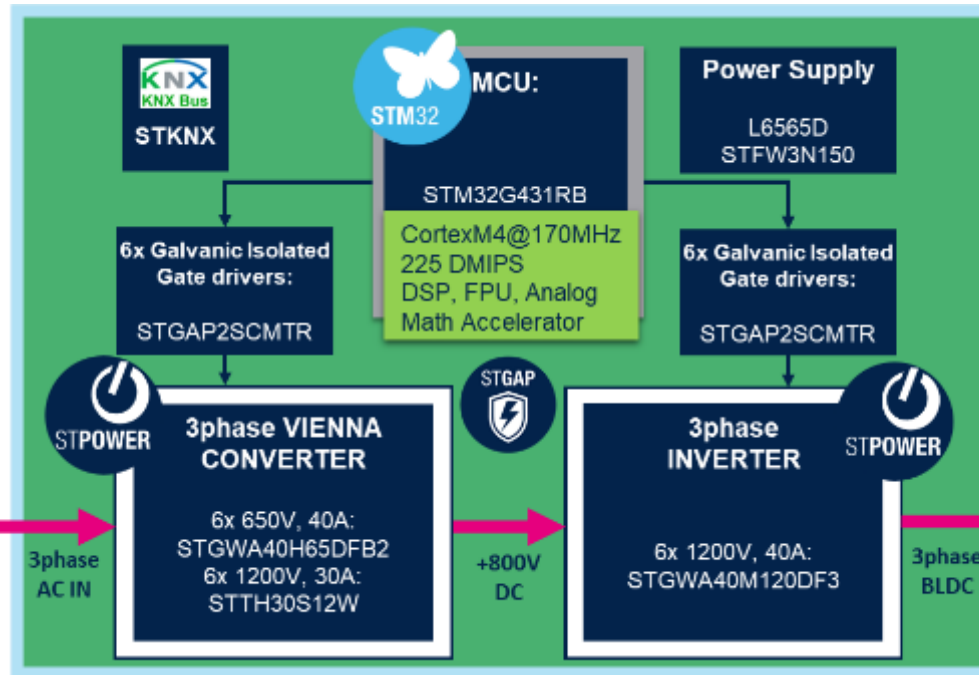
9 - 21 kW
COP ~ 3

Water

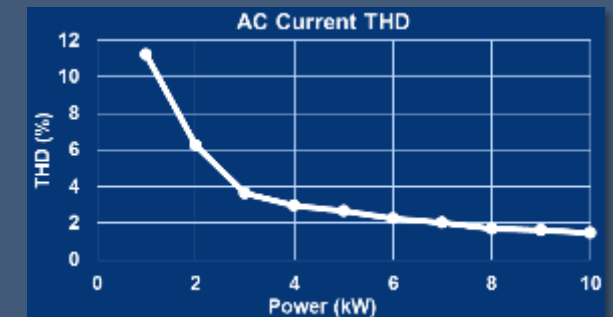




10-15 kW high-power cooling system 3-ph Vienna PFC + compressor, all-in-1



- Centralized intelligence: one STM32 drives BLDC and dPFC
- Full FW stack by ST: MC FOC SDK and digital power
- Connectivity with KNX bus
- High power density with sic power
- Low overall CPU load: 65%
- Power >30%, PFC iTHD <6%
- Max power iTHD <2%



- STM32G431RBT6
- L6565D
- STFW3N150
- TN4050-12PI
- L7912CP
- LD39100PU33R
- ST KNX module

For Compressor inverter:

- STGWA40M120DF3 * 6
- STGAP2SCMTR * 6
- TSV791ILT
- TS391RILT

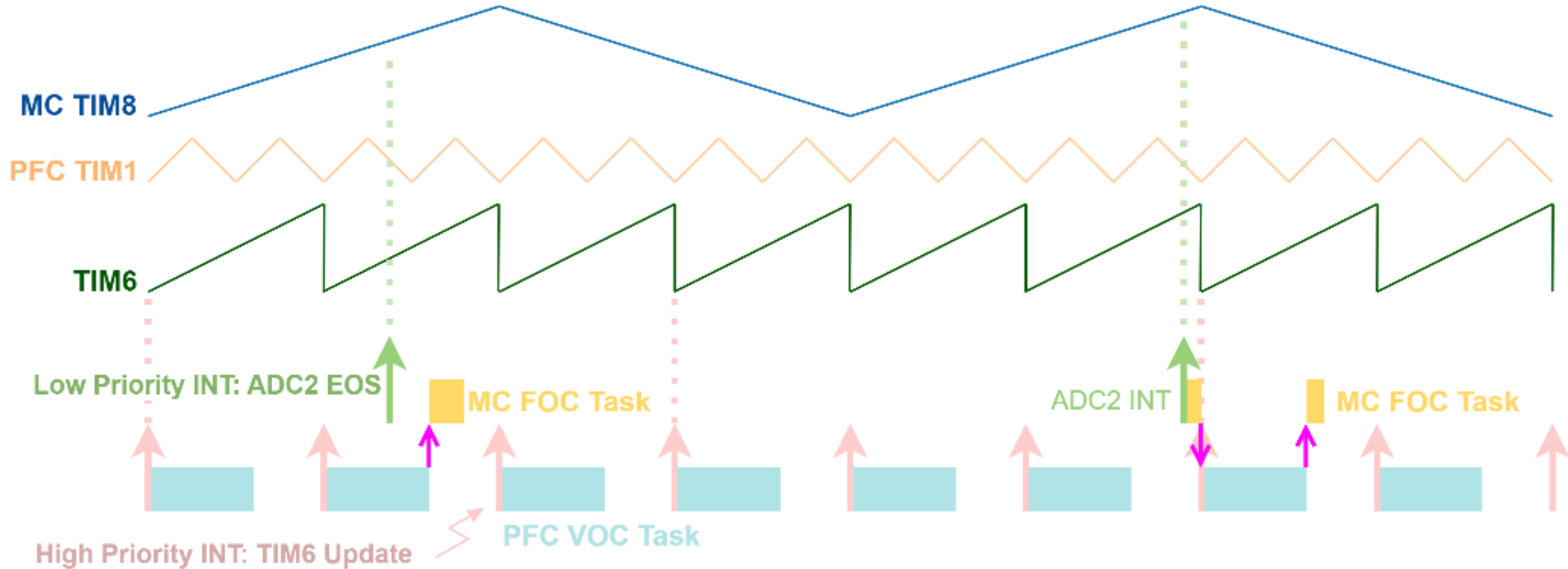
For Vienna PFC:

- STGWA40H65DFB2 * 6
- STTH30S12W * 6
- STGAP2SCMTR * 6
- TSV912A * 5
- TSV911ILT * 3

High power density with SiC MOSFET SCT040W65G3AG
STGAP3 for SiC (with DESAT)
SiC diode STPSC20G12WL



STM32G431 for Vienna PFC + compressor Motor control & Vienna integration



- 1) TIM1 is used for PFC; TIM8 is used for MC
- 2) MC FOC task is executed in ADC2 INT, @5 kHz
- 3) PFC VOC task is executed in TIM6 INT, @20 kHz
- 4) The priority of PFC task is higher than MC task.



STM32G431 For Vienna PFC + compressor

All functions in A 64-pin MCU

Function	Digital I/O	Analog I/O	Total
Compressor	7	2	9
PFC & ICL	8	9	17
USART comm	2		2
SWD debug	2		2
Other analogs		2	2
Other digitals	2		2
MCU functional			12
Unused	10	8	18
GRAND TOTAL			64

OCP & temperature sensing by MCU

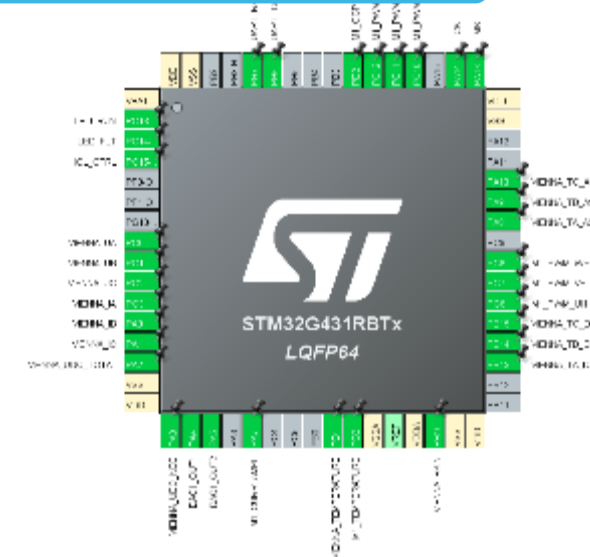
OCP & OVP by MCU

Vdd, Vss, Boot, Vdda, Vssa, NRST

Memory usage Vienna PFC + motor control:

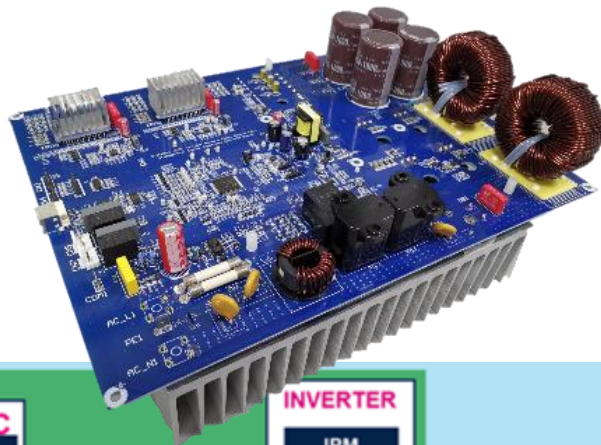
Flash: 53 KB

RAM: 14 KB



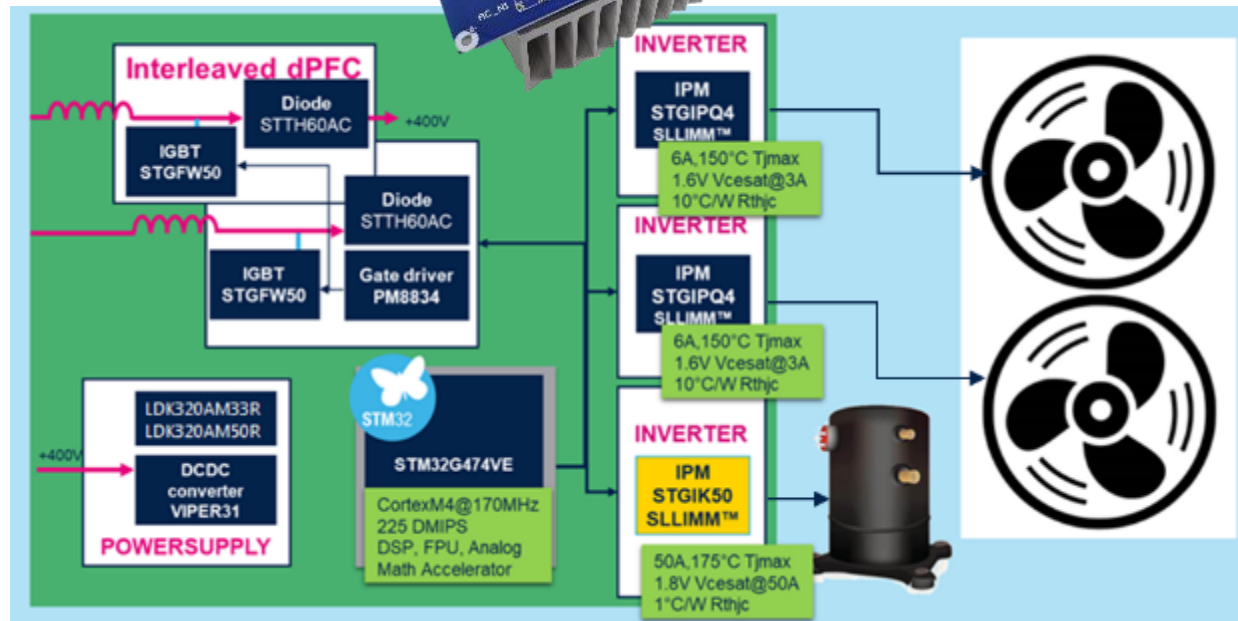


ST's new triple FOC + d-I-PFC 7kW STM32G4 worldclass comm aircon



ST Products

- STM32G474VE
- STGIK50CH65T
- 2x STGIPQ4C60T-HZ
- 2x STGWA50HP65FB2
- 2x STFW40N60M2
- 2x STTH30M06S
- 2x TSV914IPT
- ULN2003D1013TR
- VIPER318HDT
- PM8834
- LMV339IDT
- TS391RILT
- LD1117S33TR
- LD1117S50TR

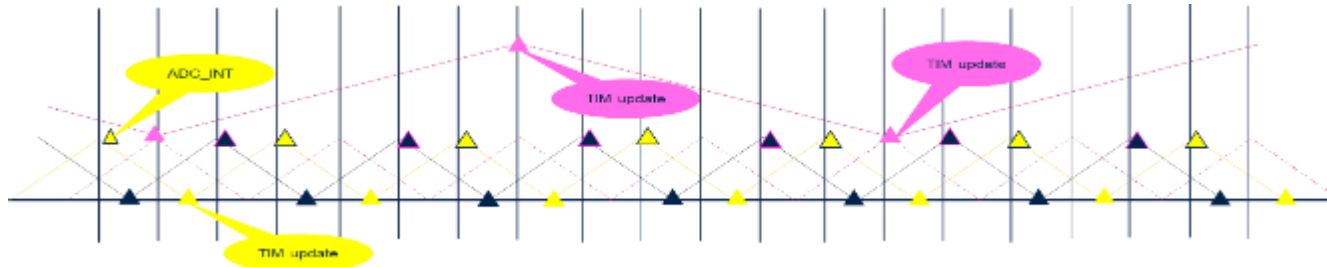


- One STM32G4 MCU only to drive all functions
 - Reduced number of components
 - No need sync between controllers
 - One FW workspace only
 - MC SDK v5.Y
- New ST HP SLLIMM 50A
 - High Energy Efficiency
- High Frequency d-i-PFC 60kHz
 - SJ MOSFET / SiC diodes
 - New Patented Single shunt

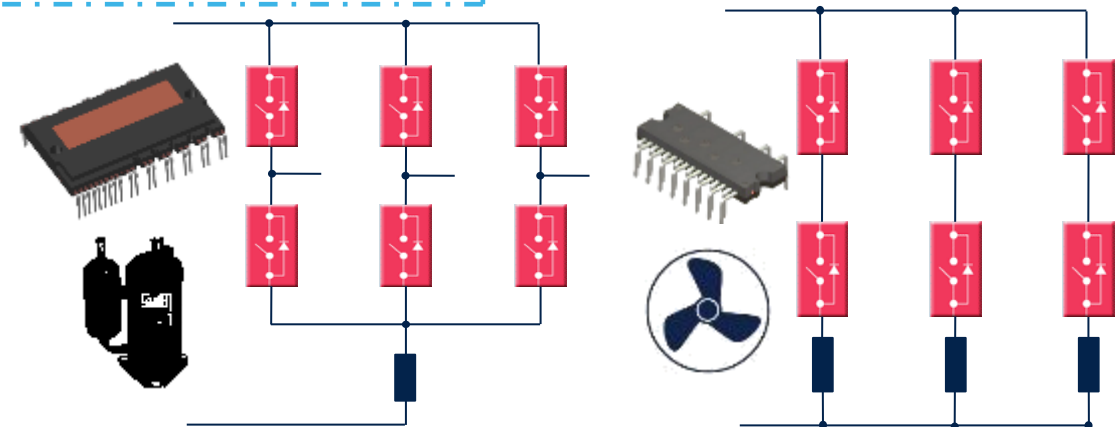
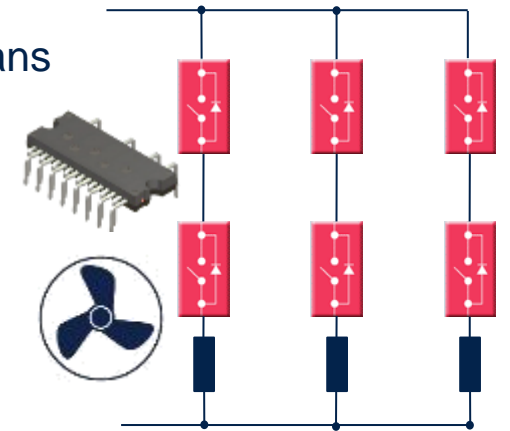
Triple FOC and current sensing topology

STM32G474 has up to 3 x 16-bit 8-channel advanced motor control timers

1. FOC library arranges so as to share CPU time between the three drives, compressor and two fans
2. Two fans has same PWM frequency which proportional to compressor's PWM frequency



1. 1 shunt for compressor to reduce BOM cost
2. 2/3 shunts for fans to enhance OTF performance and startup success rate
3. BEMF sensing network included to extend extreme conditions



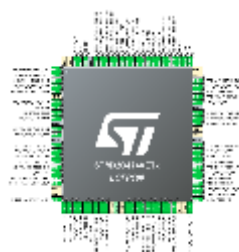


STM32G474, CPU load <55%

100-pin STM32G474 MCU + 3 IPMs

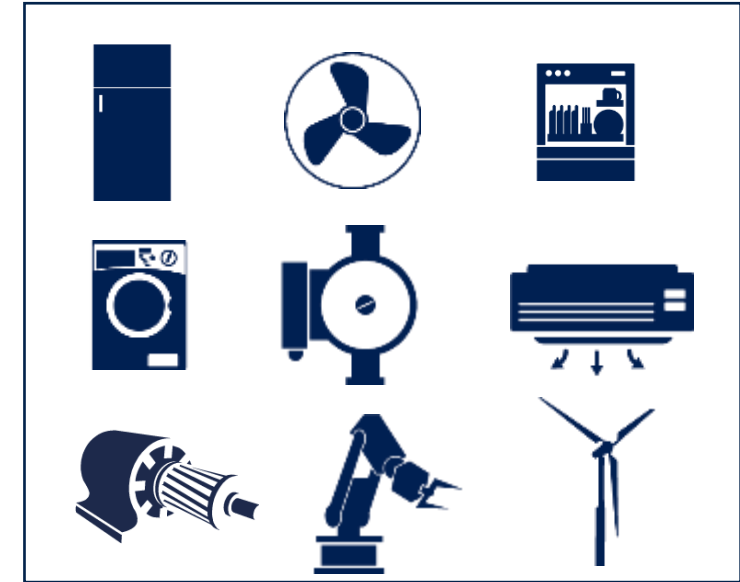
Task	PWM frequency	Control frequency	Task duration	CPU load
Compressor FOC (sensorless, 1shunt)	5 kHz	5 kHz	9.5 us	4.7%
Fan1 FOC (sensorless, 2shunt)	15 kHz	15 kHz	7.2 us	11.0%
Fan2 FOC (sensorless, 2shunt)	15 kHz	15 kHz	7.2 us	11.0%
iPFC current regulation	60 kHz	60 kHz	4.2 us	25%
iPFC voltage regulation		2 kHz	1.4 us	0.3%
Other tasks for compressor		0.5 kHz	19.8 us	1%
Other tasks for dual fan		0.5 kHz	17.9*2=35.8 us	1.8%
TOTAL				54.8%

Function	Digital I/O	Analog I/O	Total
Compressor	7	5	12
Fan1	7	7	14
Fan2	7	7	14
Interleaved PFC	6	5	11
USART comm	4		4
SWD debug	2		2
I2C EEPROM	2		2
Stepper valves	6		6
Other analogs		8	8
Other digitals	3		3
MCU functional			14
Unused	6	4	10
GRAND TOTAL			100



Trench gate field-stop IGBTs

The right solution for motor control



600V H series

- Low V_{CESAT} : 1.5 V-1.6 V
- Current capability: 4A(*) to 20A in discrete pkg
- Available also in bare die
- t_{SC} of 5 us at $T_J=25^\circ\text{C}$, $V_{CC} \leq 360\text{V}$
- $T_J \text{ max} = 175^\circ\text{C}$

STGD4H60DF
Available

New

650V M series

- Low V_{CESAT} : 1.55 V - 1.65 V
- Current capability: 4A to 200A in discrete pkg
- Available also in bare die
- t_{SC} of 6 μs at $T_J= 150^\circ\text{C}$, $V_{CC} \leq 400\text{V}$
- $T_J \text{ max} = 175^\circ\text{C}$

1200V M series

- V_{CESAT} : 1.85 V
- Current capability: 8 to 50A in discrete pkg
- Available also in bare die
- t_{SC} of 10 μs at $T_J= 150^\circ\text{C}$, $V_{CC} \leq 600\text{V}$
- $T_J \text{ max} = 175^\circ\text{C}$

STGYA50M120DF3
available

New

1700V M series

- V_{CESAT} : 2 V
- Current capability: 50A
Available only in bare die (D7,D8)
- t_{SC} of 10 μs at $T_J= 125^\circ\text{C}$, $V_{CC} \leq 1000\text{V}$
- $T_J \text{ max} = 150^\circ\text{C}$

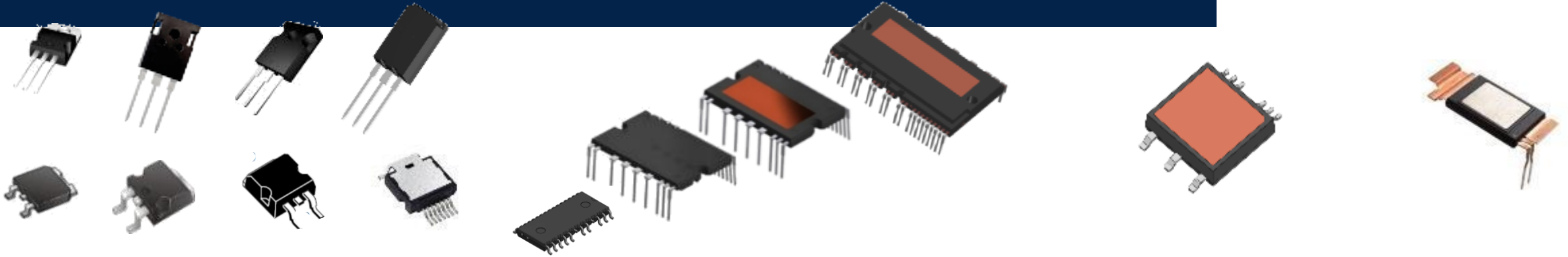
STG50M170F3D7/D8 Available

New



IGBT & IPM power product portfolio

High innovation, from discretes to power modules



Discrete IGBT

SLLIMM IPM

ACEPACK SMIT & STPAK

Typical power: 10 W to 5 kW

Typical power: 20 W to 7 kW

Typical power: 3 kW to 300 kW



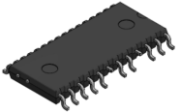

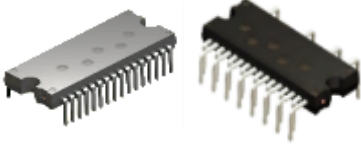


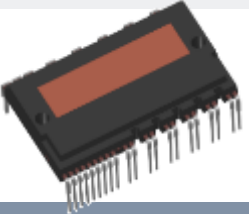
Ideal solutions for Industrial & Robotic Drives, Home Appliances, Welding, Pumps, Fans & Blowers, Air Conditioning, and EV



SLLIMM

Small low-loss intelligent molded module



SLLIMM nano			SLLIMM 2 nd series		SLLIMM HP
SMD	TH	2 nd series TH	Full molded	DBC	
600 V IGBT 500 V MOSFET 1 up to 3 A	600 V IGBT 3 A	600 V IGBT 600 V SJ-MOSFET 3 up to 8 A	600 V IGBT 8 up to 15 A	600 V IGBT 600 V SJ-MOSFET 12 up to 35 A	IGBT 650 V, 50 A ★ 1200 V, 10 A
					
NSDIP-26L 12.45 x 29.15 x 3.10 mm	NDIP-26L 12.45 x 29.15 x 3.10 mm	N2DIP-26L 12.45 x 32.15 x 4.10 mm	SDIP2F-26L 24 x 38 x 3.5 mm	SDIP2B-26L 24 x 38 x 3.5 mm	SDIPHP-30L 31 x 52 x 5.6 mm

10 to 600W						300W to 3kW			3 to 7kW		
											



★ AG on going

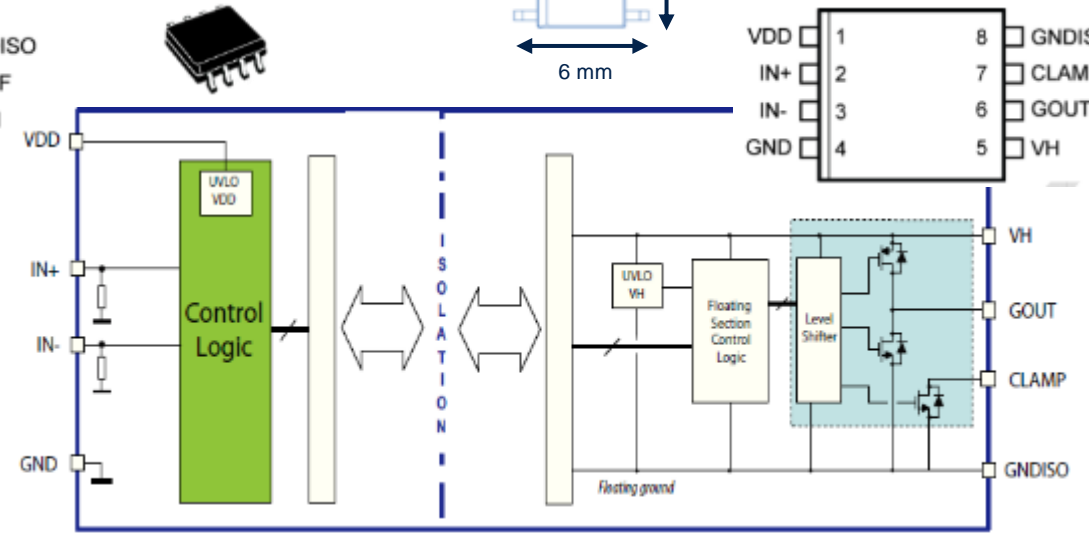
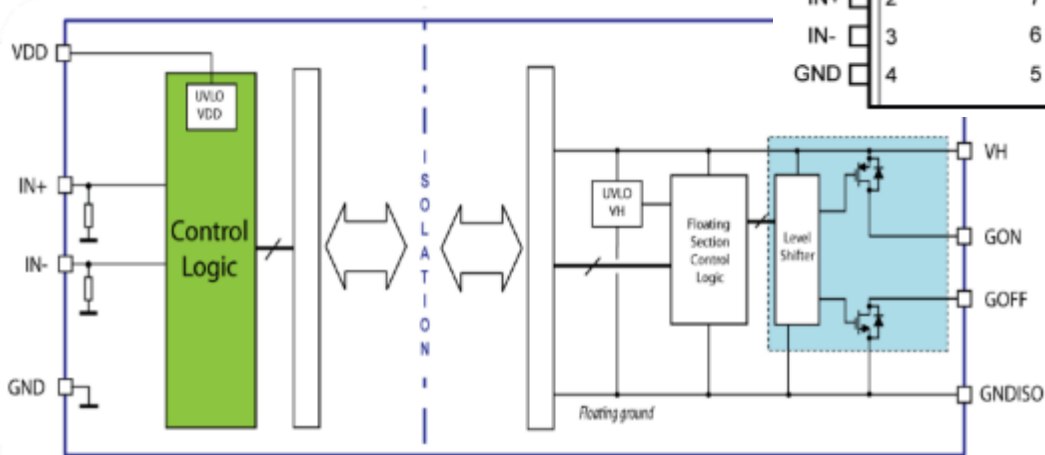
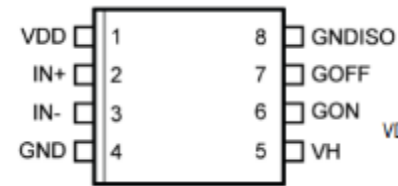
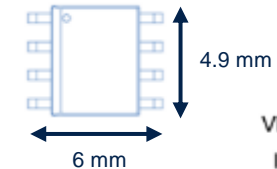
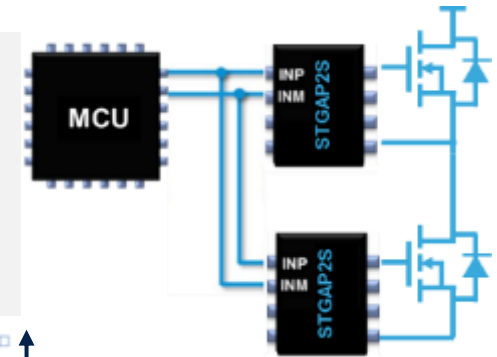


STGAP2S, STGAP2SICSN

4000 V, 4A functional isolated gate drivers

- 3V3 / 5 V logic inputs (logic thresholds 1/3, 2/3 of VDD)
- **Up to 26 V supply voltage**
- **4 A Sink/Source current capability**
- Short propagation delay: 75 ns
- UVLO function (Si MOS-IGBT & SiC options)
- Standby function
- 100 V/ns CMTI
- Basic isolation 4000Vpeak
- Thermal shut-down protection

- Active high & active low input pins, for HW interlocking
- **STGAP2SM, STGAP2SICSN:**
Separated outputs option for easy gate driving tuning
- **STGAP2SCM, STGAP2SICSNC:**
Miller CLAMP pin option to avoid induced turn-on
- SO-8 package (narrow body)





STGAP3S

Single channel, 1200V gate driver for SiC MOSFET and IGBTs with reinforced isolation and desaturation protection

10 kV reinforced galvanic isolation

Up to 10A current capability

Miller clamp function (Int / Ext)

Desaturation protection

Key applications

- Industrial motor drives and fans
- Charging stations
- Industrial inverters
- Power supplies units
- PFC & DC-DC converters
- Factory automation



Features

$V_H < 32V$; $V_L > -10V$

3 current capability options: 3A, 6A, 10A

Miller Clamp: Int up to 3A / Ext driver from 6A

DESAT protection: soft / tunable turnOFF

Monitoring pins: DIAG and RDY

SO16W

SO16W package

- 8 mm LV to HV creepage
- 1.27 mm pitch



STM32G4 with rich, advanced analog

Mixed-signal SoC for a wide variety of applications

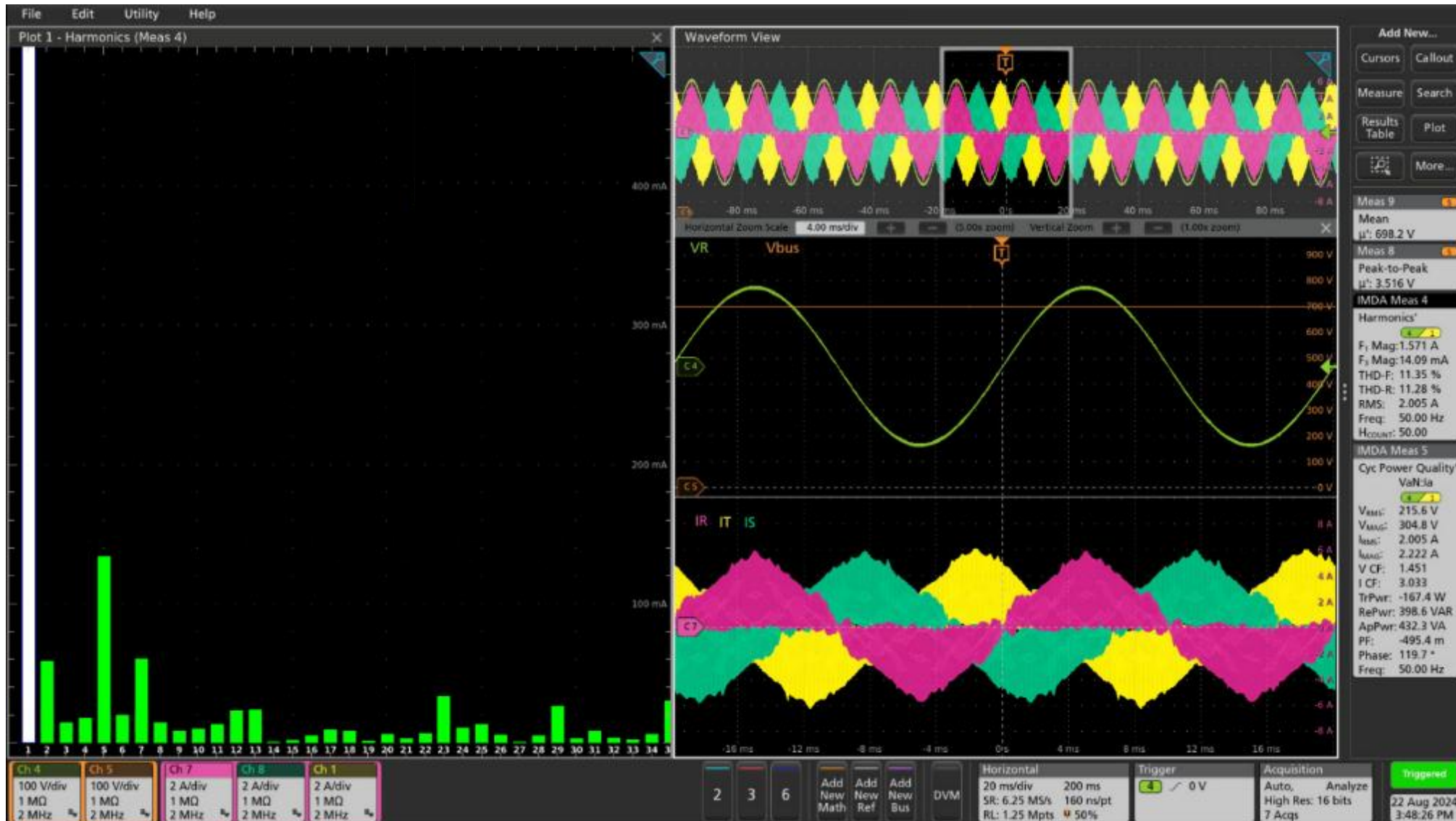
ADC (up to 5)	Values
Topology	SAR 12-bit + hardware oversampling → 16-bit
Sampling rate	Up to 4 Msps
Input	Single-ended and differential
Offset and Gain compensation	Autocalibration to reduce gain and offset

DAC (up to 7)	Values
Sampling rate	15 Msps (internal) 1 Msps (from buffered output)
Settling time	16 ns

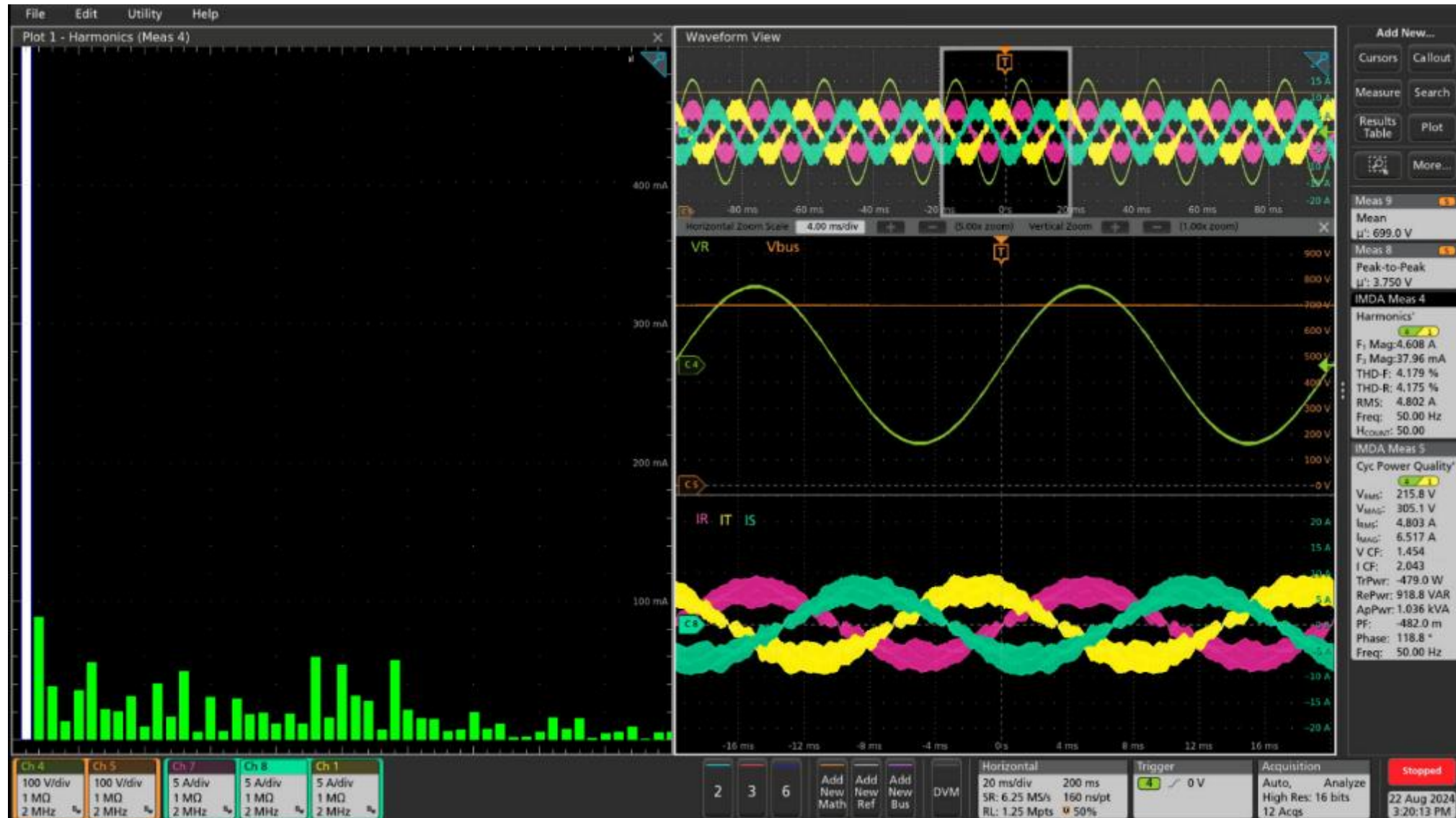
Op amp (up to 6)	Values
GBW	13 MHz
Slew rate	45 V/μs
Offset	3 mV over full T° range 1.5 mV @ 25°C
PGA Gain (accuracy)	2, 4, 8, 16, -1, -3, -7, -15 (1%) 32, 64, -31, -63 (2%)

Comparator (up to 7)	Values
Power supply	1.62 .. 3.6 V
Propagation delay	16.7 ns
Offset	-6 .. +2 mV
Hysteresis	8 steps: 0, 9, 18, 27, 36, 45, 54, 63 mV

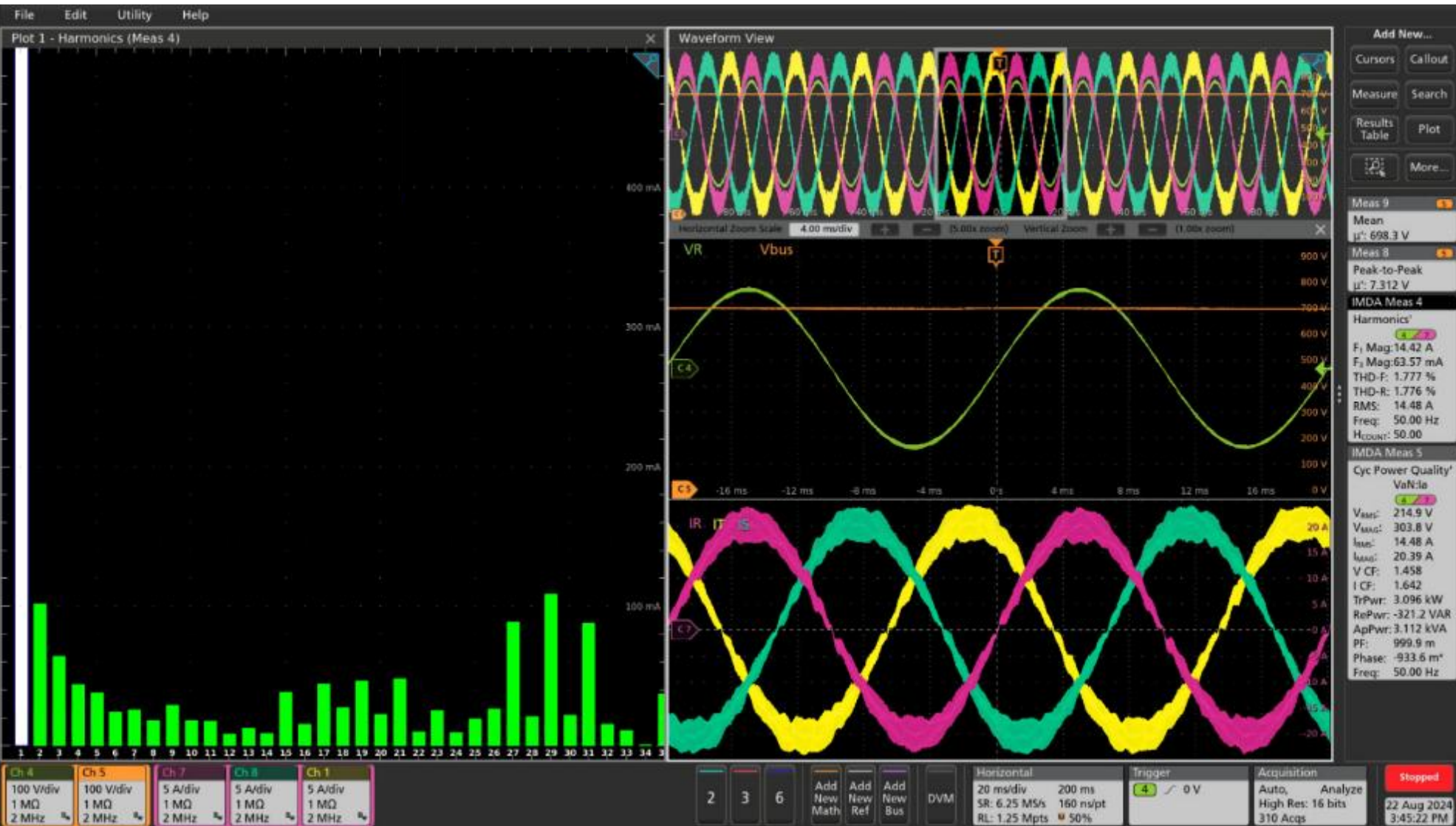
Experimental: Vienna PFC @ 1 kW



Experimental: Vienna PFC @3 kW



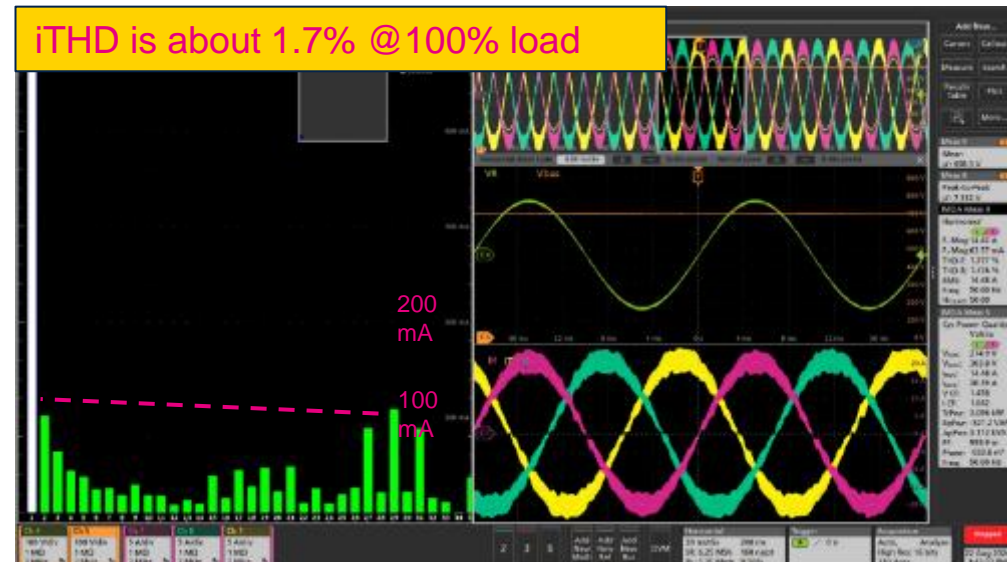
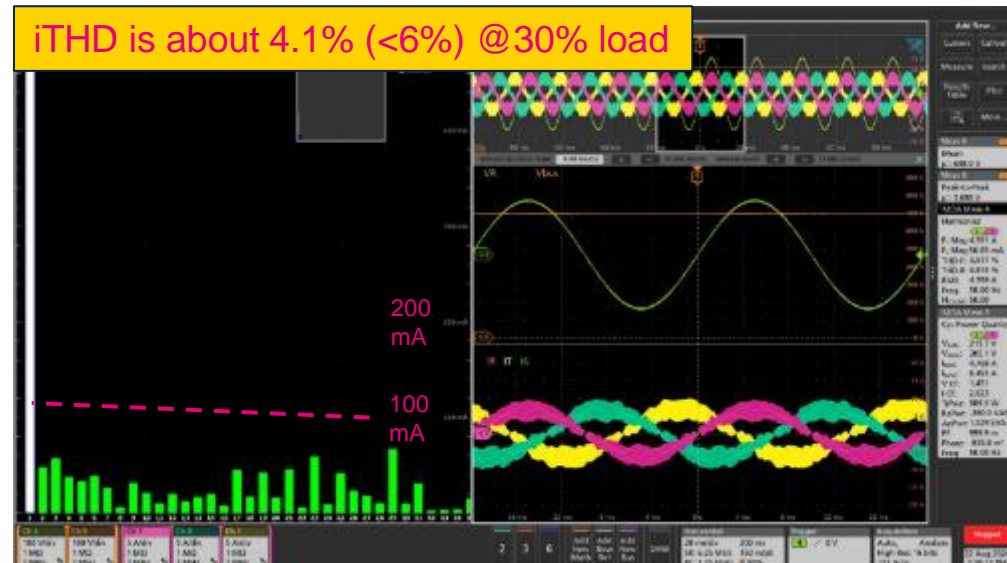
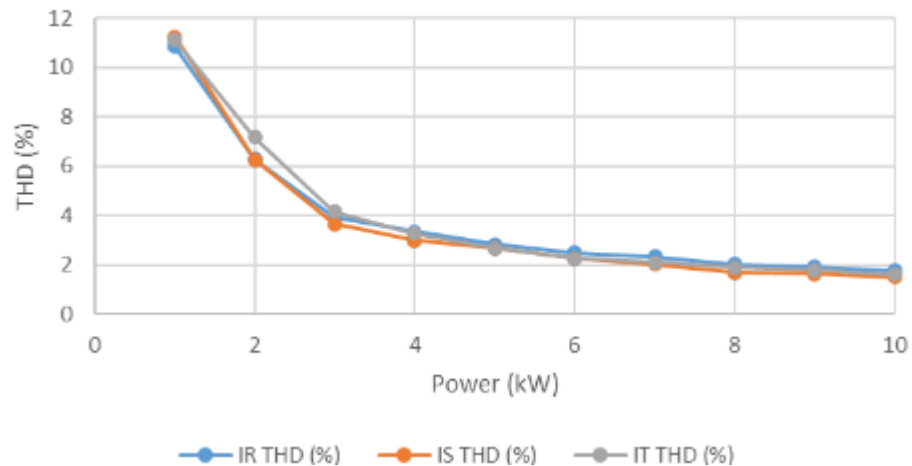
Experimental: Vienna PFC @ 10 kW



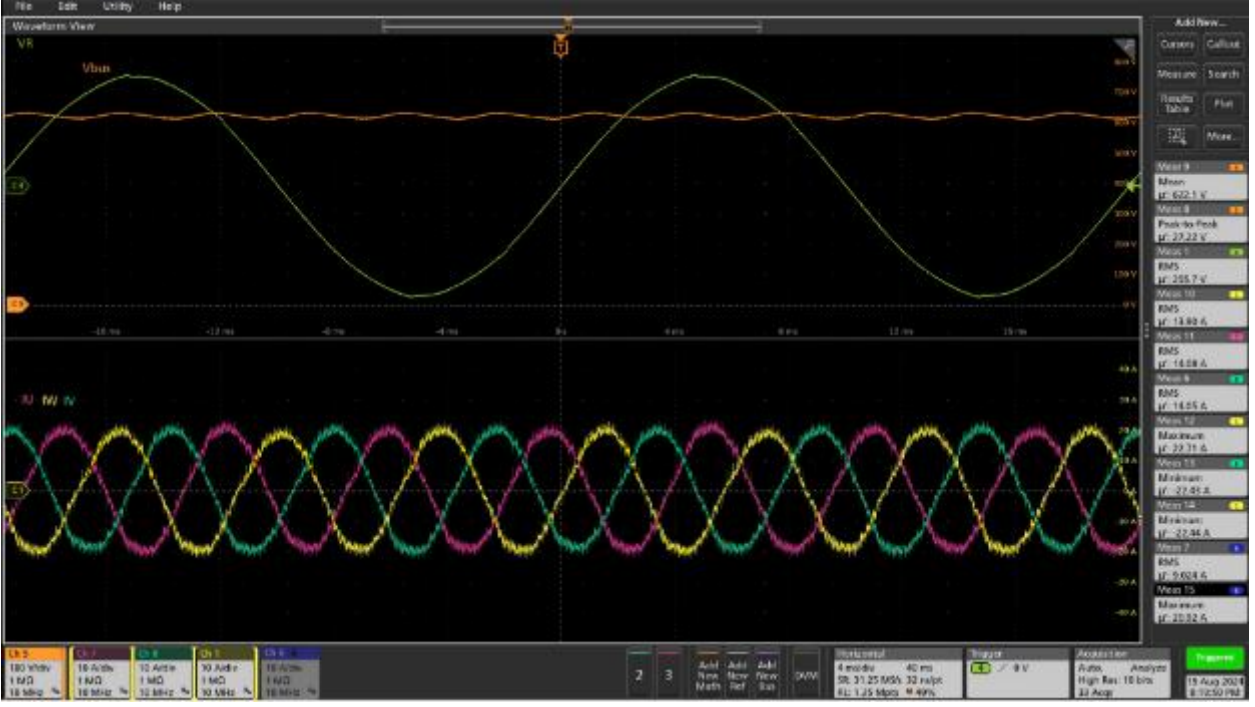
Experimental: iTHD result

Power (kW)	IR THD (%)	IS THD (%)	IT THD (%)	Vbus ripple (V)
1	10.87	11.25	11.11	3.734
2	6.285	6.258	7.164	3.562
3	3.917	3.649	4.156	3.688
4	3.351	2.974	3.272	4.094
5	2.833	2.678	2.665	4.703
6	2.499	2.257	2.254	4.781
7	2.335	2.019	2.093	5.094
8	2.02	1.691	1.892	5.703
9	1.917	1.641	1.802	6.922
10	1.777	1.493	1.6	7.312

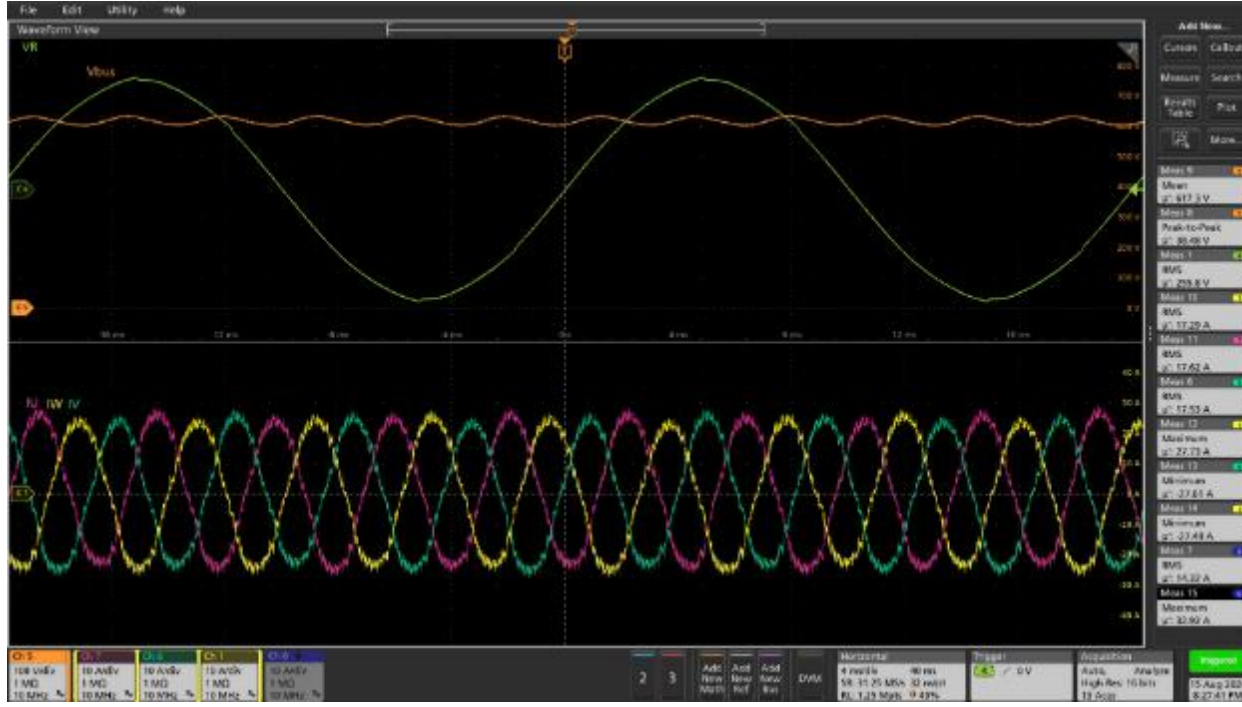
AC Current THD



Experimental: Compressor



5 kW

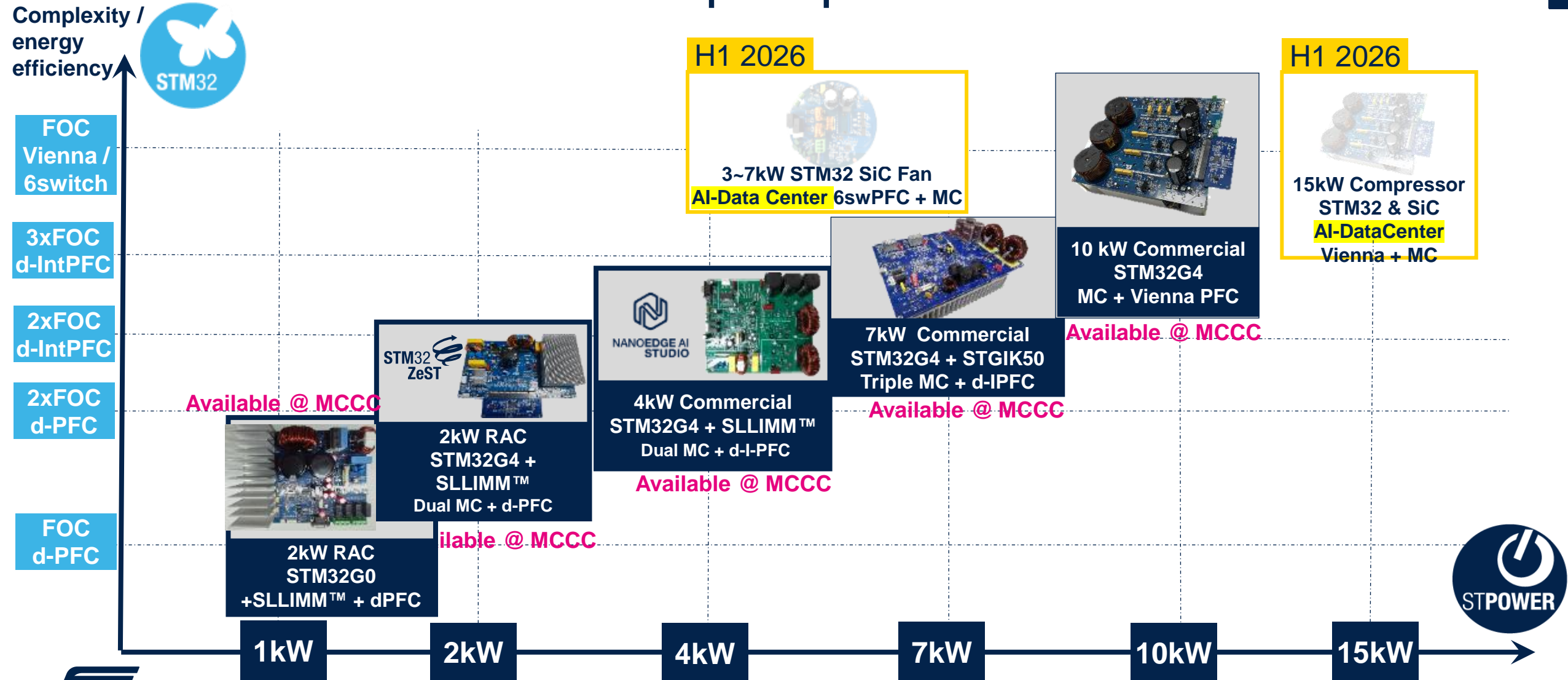


10 kW





Solutions and Roadmap for HVAC / Heatpump / BESS / AI Data Centers



Part numbers are indicative only. Final BOM to be agreed with ST's Sales & Marketing local representatives



Motor Control Ecosystem For STM32

Visit the STM32 motor control dedicated web page:
www.st.com/stm32-motor-control

Motor Control Suite

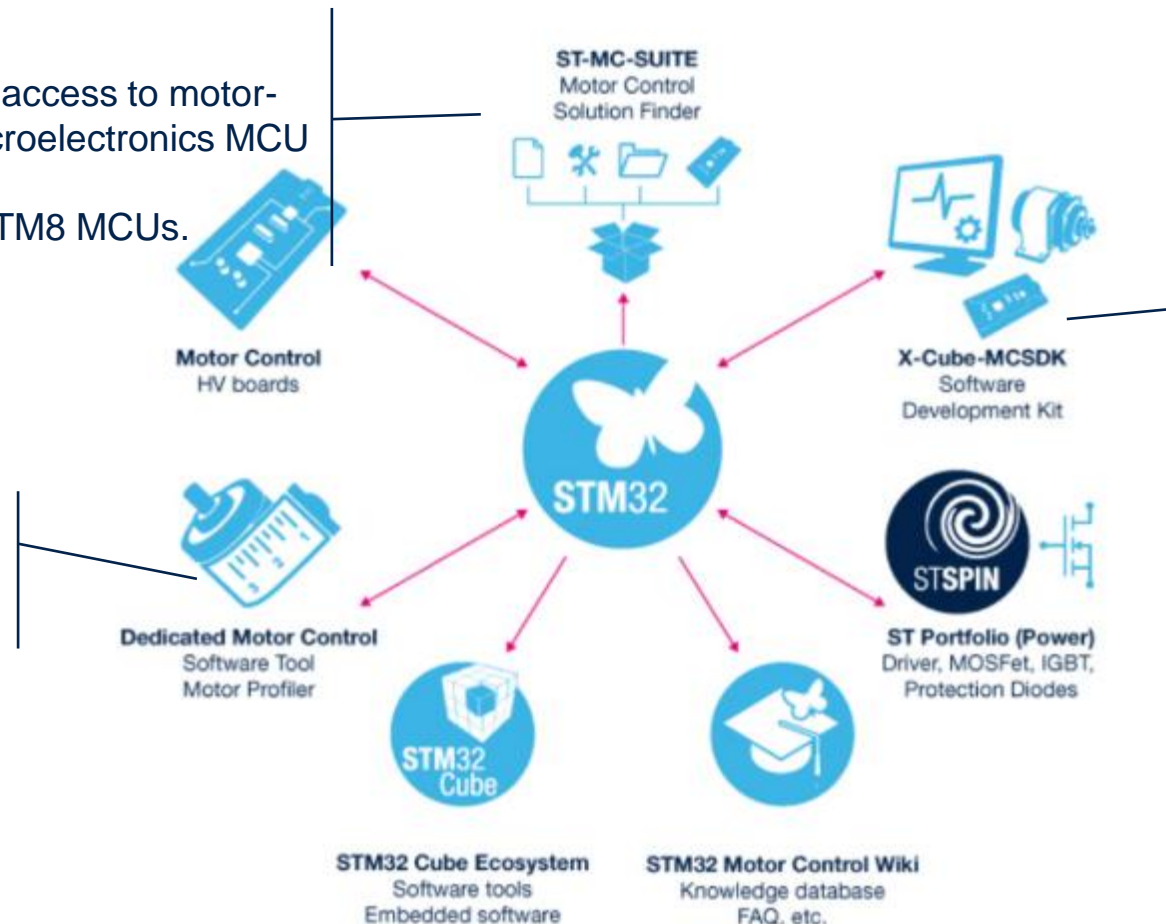
- Online tool that provides easy access to motor-control resources in the STMicroelectronics MCU ecosystem
- For STM32, STSPIN32 and STM8 MCUs.

Motor Control SW Dev. Kit (SDK)

- Motor Control FW lib: full feature library
- Motor Control Workbench: Graphical (GUI) configurator/monitor
- For STM32, STSPIN32 MCUs.

Motor control Profiler

- Automatic detection of key parameters (Rs, Ls, Ke)
- Zero equipment required
- For STM32 MCUs.



Our technology starts with You



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