

Murata Power update

March 2018

For distribution to distributors

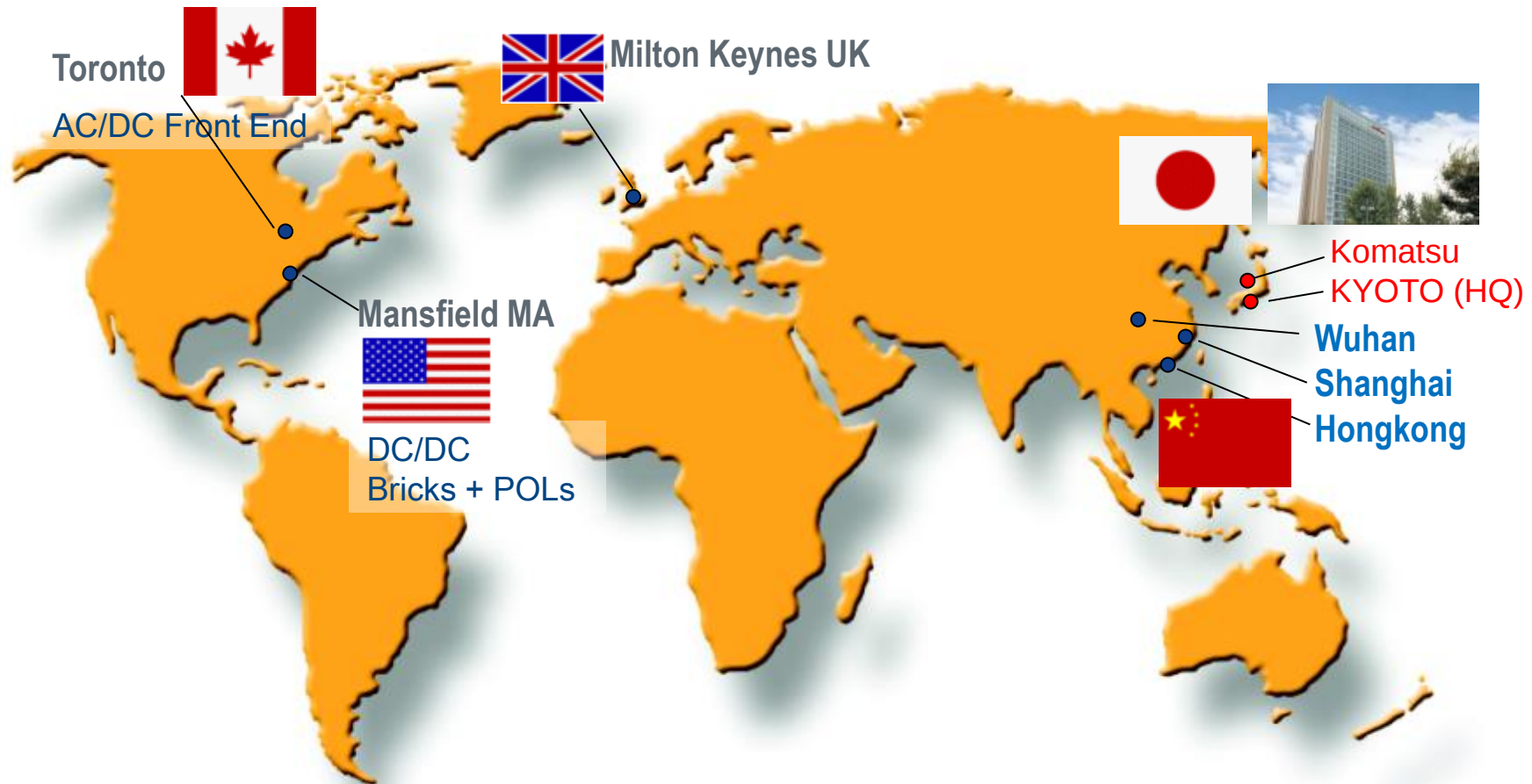


Murata Power

in a nutshell



Murata Power Main Design Locations

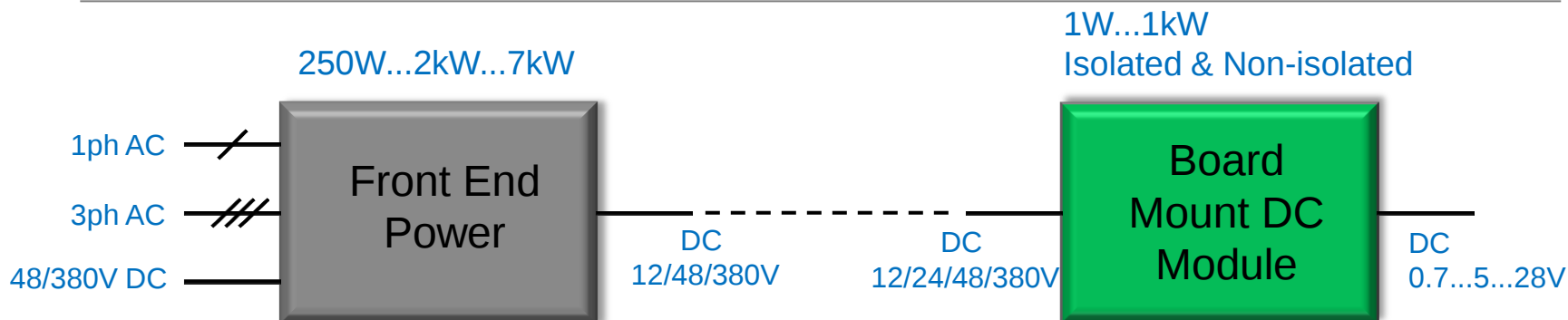


...global footprint with Engineering presence throughout the world

© Iryna Volina (fotolia) / europakarte.org



Murata Power Major Product Areas



Target application

- Datacom, Computing
- Data Centre

Strength

- High power density
- High efficiency (80+ Titanium)
- Reliability
- Industry standard formfactors & Customization



Target application

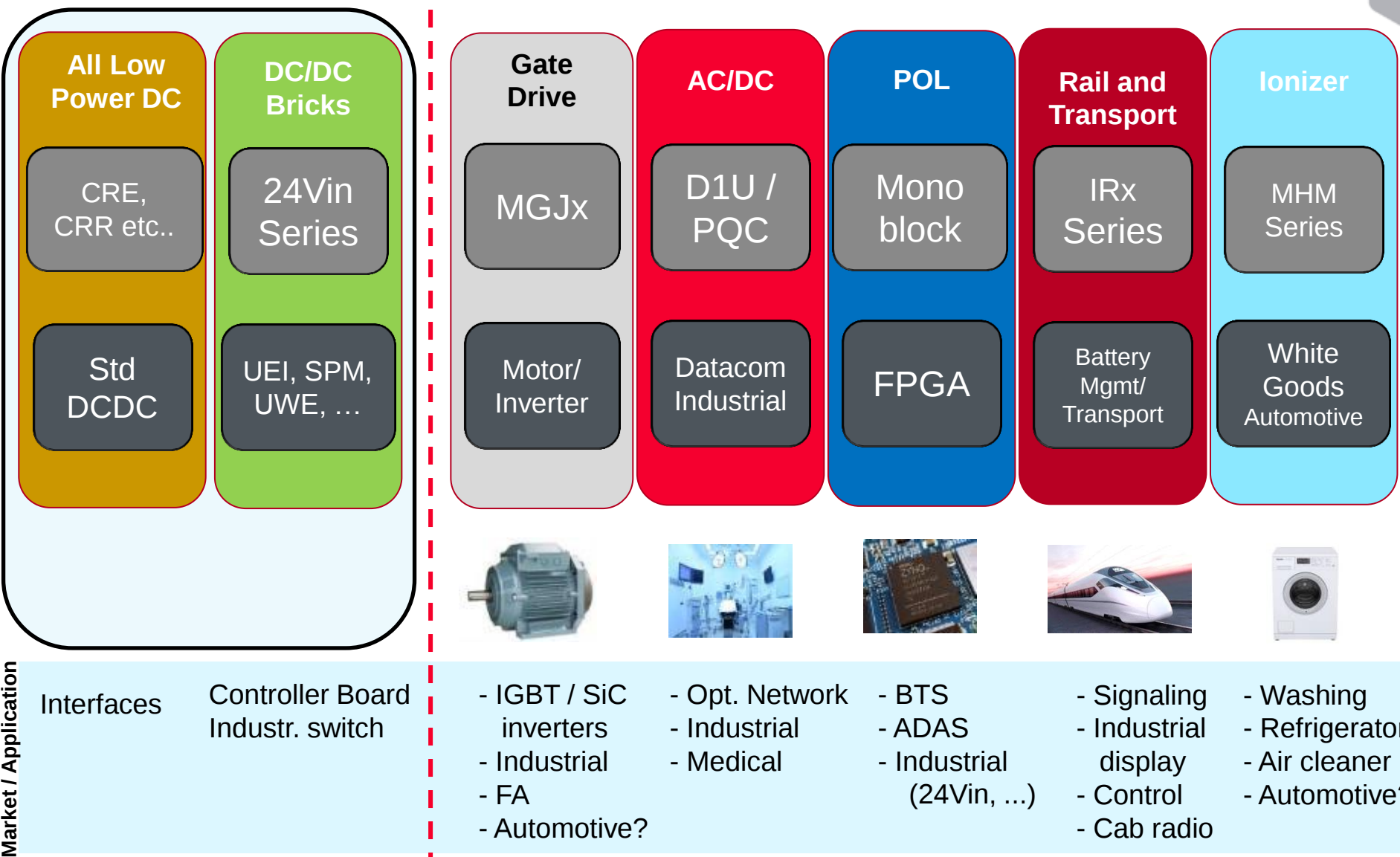
- Datacom, Telecom, Computing
- Industrial, Medical

Strength

- Reliability
- High power density
- Innovative
- Packaging technology

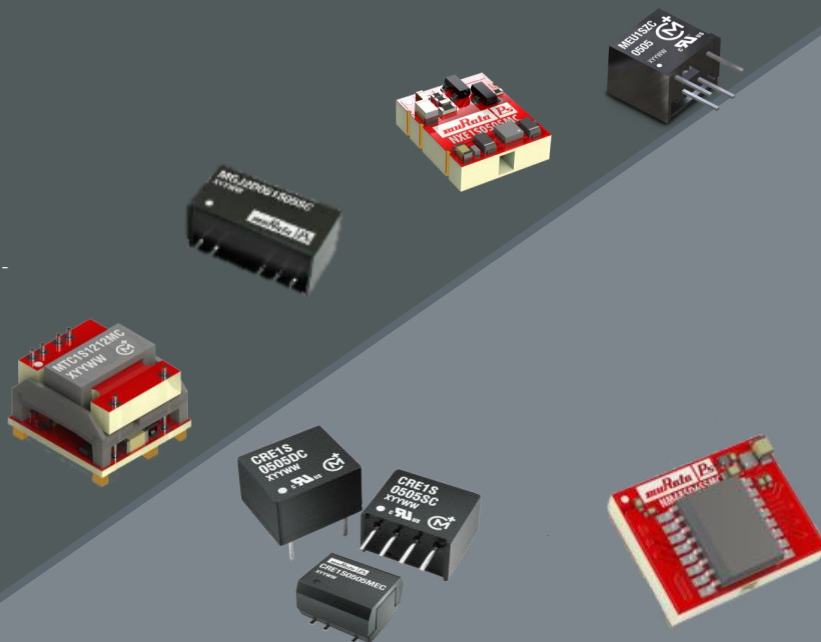


Focussed Product lines in 2018

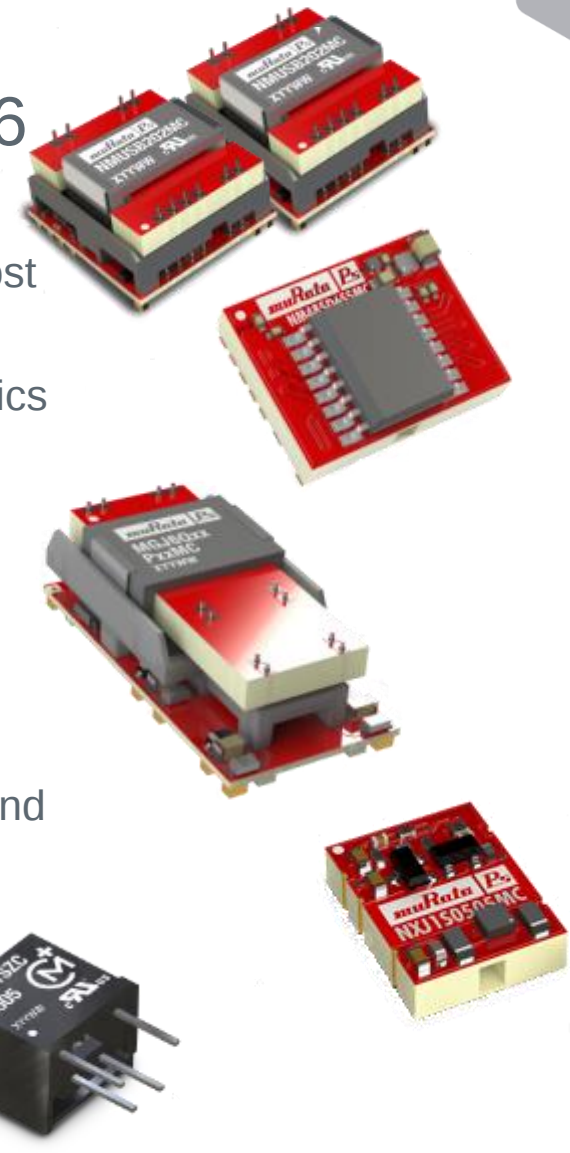


Market / Application

New Low Power DC/DC modules



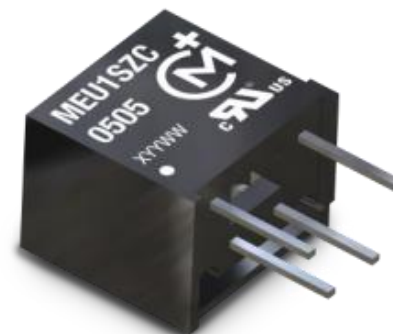
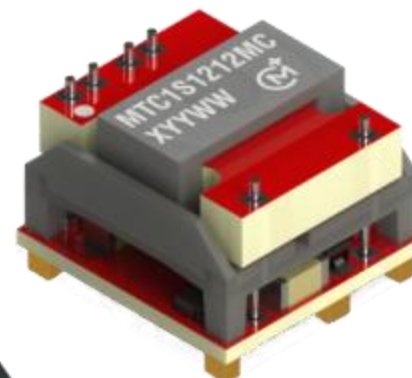
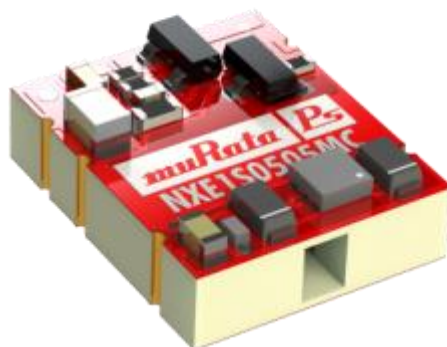
- Eg: NMUSB, NMTTL, NM485, MGJ1/3/6
 - Competition is mainly Discrete solution
 - Comparison between Discrete Solution BOM and Module cost fallacious. Ask for an analysis from NCL
 - Value is in functionality, ease of use, safety approvals, logistics cost, design cost, opportunity cost, time to market
- Eg: NXE, NXJ, MTU, MEU
 - Unique technology for low profile and high isolation(NXE & NXJ)
 - Unique construction for high power density with wide input and high isolation(MTU), fixed input (MEU & MTU)



'Best in Class' products

Better than comparable competition in some way

- NXE & NXJ
 - Lower profile
 - Higher isolation
 - Better repeatability
- MTC1/2
 - Smaller footprint
 - Higher isolation
 - More functionality (trim)
- MTU
 - Smallest 1W/2W SMT
- MEU
 - Smallest 1W Thru-hole

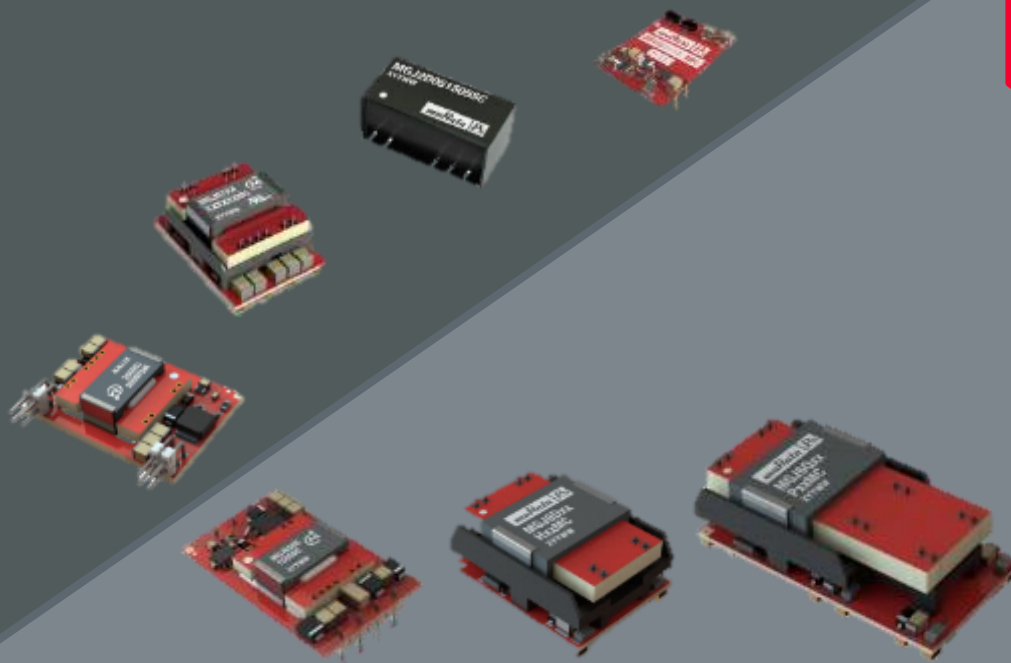


Competitive selection of standard products

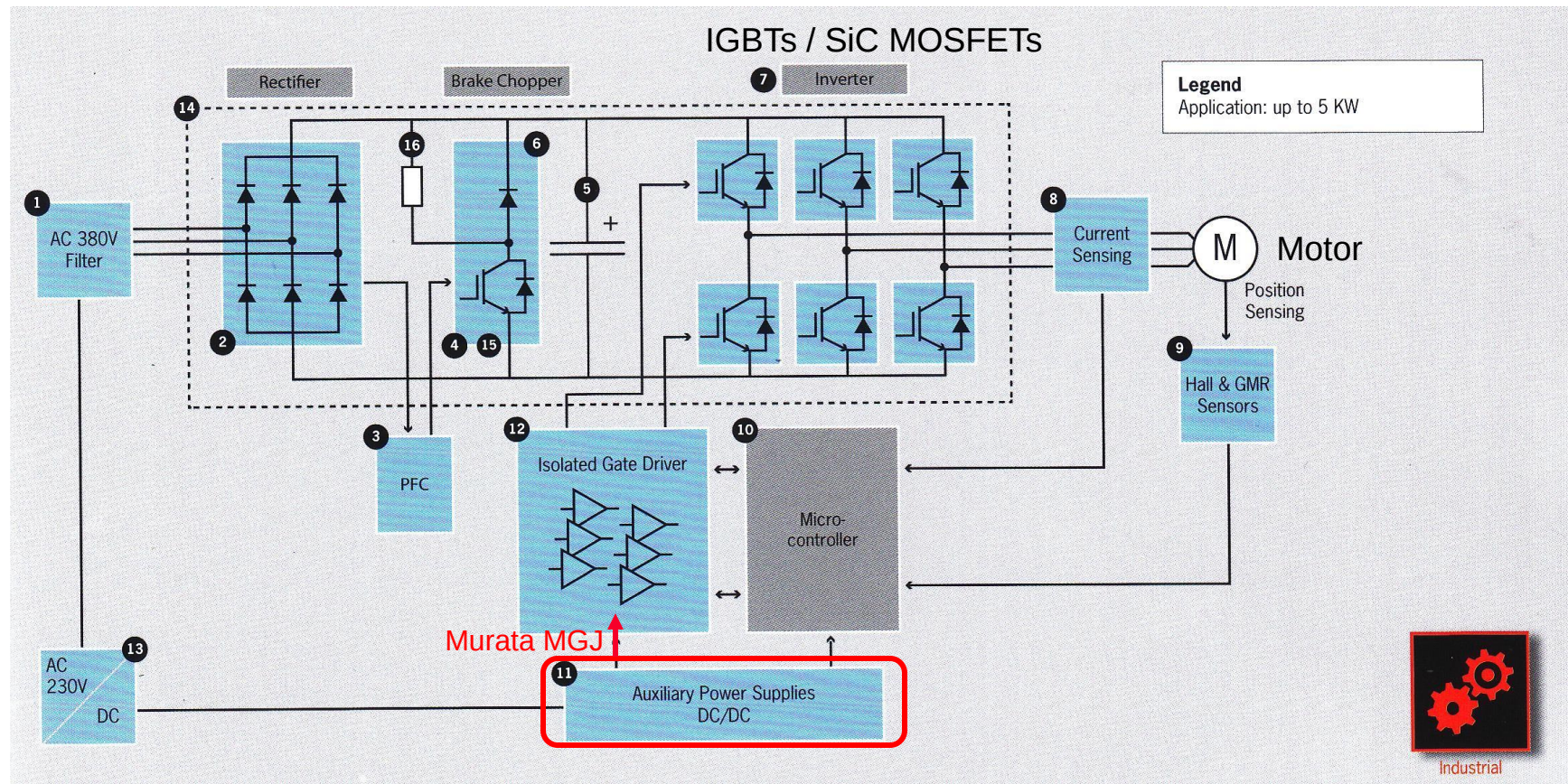
- Eg: CME, CMR, CRE1(T/H), CRE1(SMT), CRR1, CRV1, CRV2, CRL2
 - Compatible with highest runners NME, NMR, NMV, NML
 - Can match European competitor pricing
 - Match competitor performance
 - Selected range – more variants possible



DC/DC modules for IGBT, MOSFET, SiC drivers



Application example



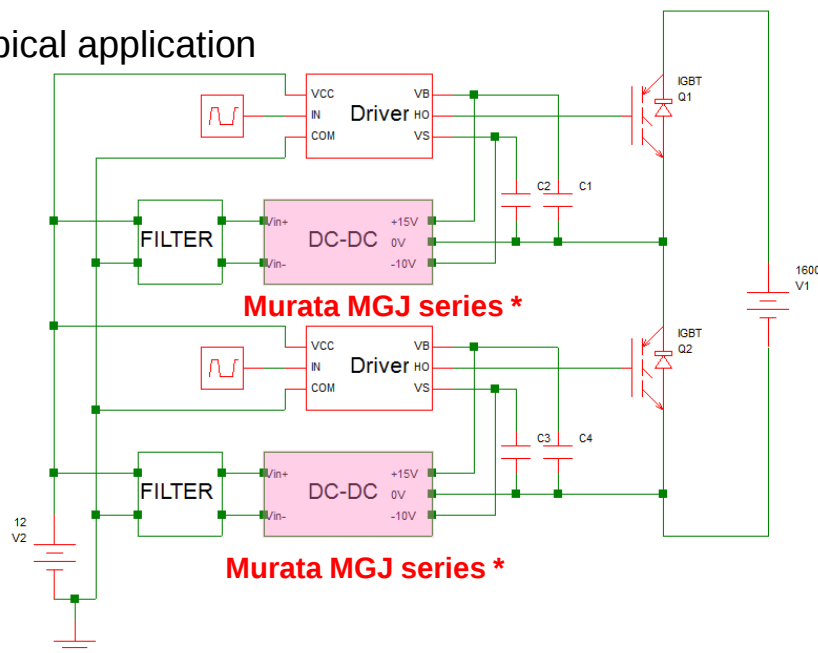
DC-DC for Gate Drivers

MGJ features

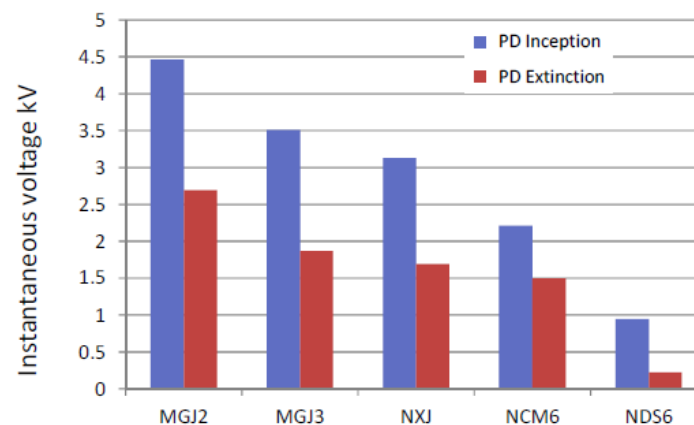
- dV/dt rating tested up to 80kV/ μ s
- Partial Discharge performance characterised
- Low coupling capacitance (2pF...15pF)
- SMT and THT available
- Space saving
- Suitable for 1kV...3kV DC-Bus voltage
- 1...6W output power
- Single & Multi channel output versions



Typical application



Partial Discharge inception and extinction voltages for various DC-DC converters



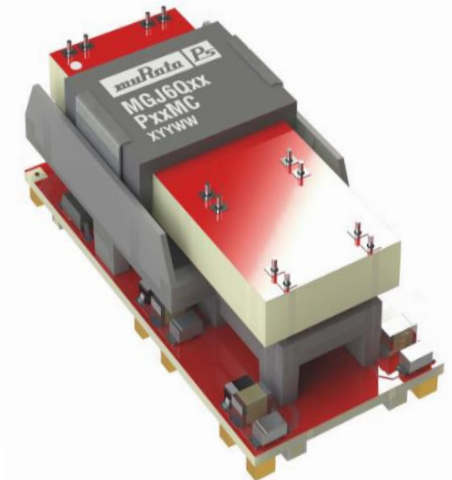
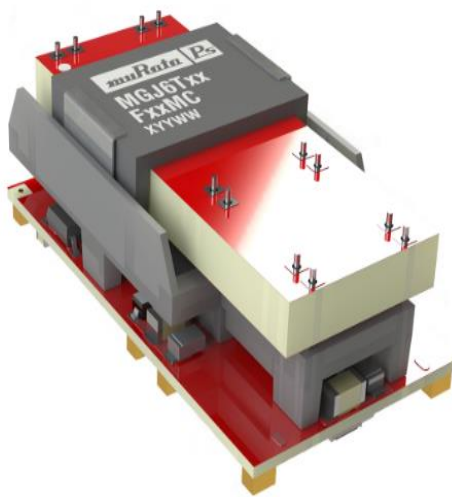
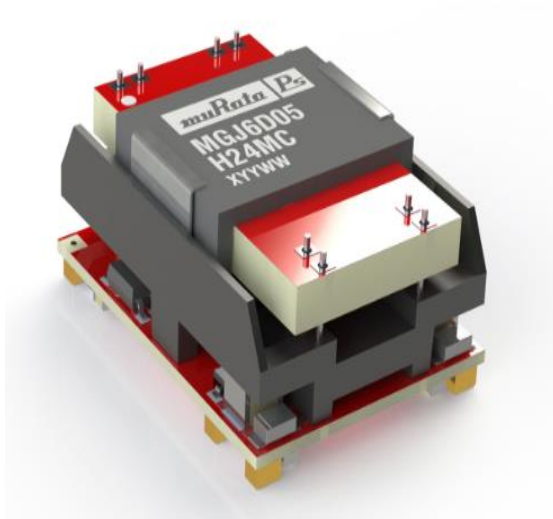
MGJ Product overview

Power	Comments	Coupl Cap	Packaging	Murata Series	
1 Watt	1 Channel; Embedded transformer	2 pF	SMD, low profile	MGJ1	
2 Watt	1 Channel; Embedded transformer	2 pF	SMD, low profile	MGJ2 (coming soon)	
2 Watt	1 Channel; Fixed outputs	4 pF	THT, SIP7	MGJ2	
3 Watt	1 Channel; Configurable outputs	15 pF	SMD	MGJ3T	
6 Watt	1 Channel; Configurable outputs	15 pF	SMD	MGJ6T	
6 Watt	1 Channel; Fixed outputs	15 pF	SMD low profile, THT SIP + DIP	MGJ6-LP, -SIP, -DIP	
6 Watt	2 channels for Half-Bridge	15 pF	SMD	MGJ6H	
6 Watt	3 channels for Full-Bridge	15 pF	SMD	MGJ6F	
6 Watt	4 channels for 3~ Bridge	15 pF	SMD	MGJ6P	
6 Watt	1 channel; 14mm cr/cl for 690Vac reinforced isolation	15 pF	SMD	MGJ6W	

dV/dt rating up to 80kV/ μ s and Partial Discharge performance characterised

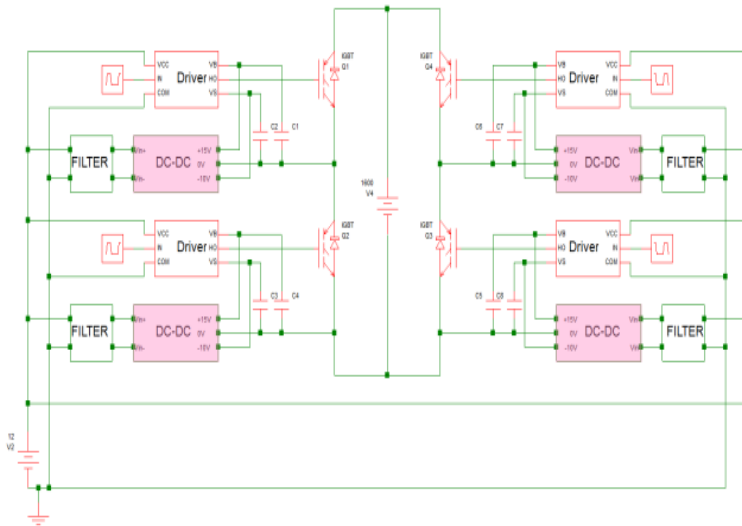
New Family of IGBT DCDC converters

- Half Bridge, Full Bridge and 3-Phase solutions



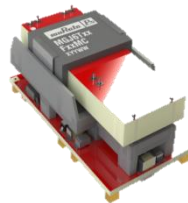
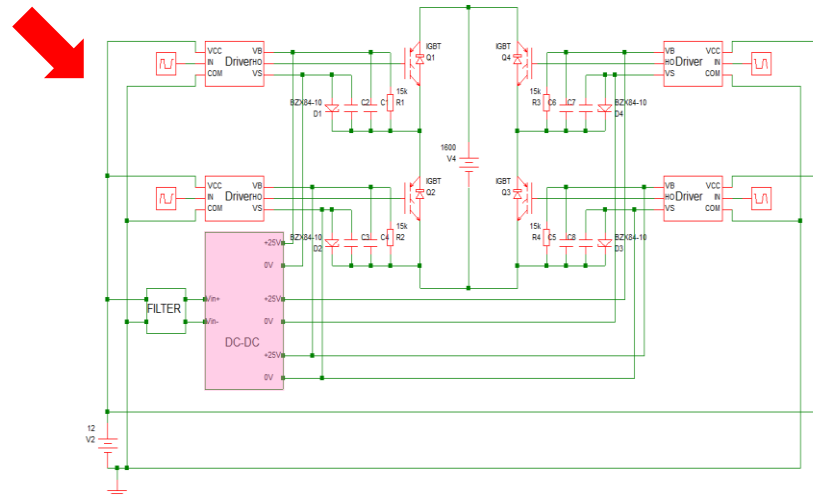
Concept of HB, FB and 3P solutions

- Reducing complexity



4 DC/DC modules replaced with 1 DC/DC module

Full-Bridge



1 Watt

MGJ1 : http://www.murata-ps.com/datasheet?http://www.murata-ps.com/data/power/ncl/kdc_mgj1.pdf

2 Watt

MGJ2 : http://www.murata-ps.com/datasheet?http://www.murata-ps.com/data/power/ncl/kdc_mgj2.pdf

3 Watt

MGJ3T : http://www.murata-ps.com/datasheet?http://www.murata-ps.com/data/power/ncl/kdc_mgj3.pdf

6 Watt

MGJ6T : http://www.murata-ps.com/datasheet?http://www.murata-ps.com/data/power/ncl/kdc_mgj6scdc.pdf

MGJ6D – SIP/DIP : http://www.murata-ps.com/datasheet?http://www.murata-ps.com/data/power/ncl/kdc_mgj6scdc.pdf

MGJ6D – Low Profile: http://www.murata-ps.com/datasheet?http://www.murata-ps.com/data/power/ncl/kdc_mgj6lp.pdf

MGJ6H - Halfbridge: http://www.murata-ps.com/datasheet?http://www.murata-ps.com/data/power/ncl/kdc_mgj6-hb.pdf

MGJ6F – Fullbridge : http://www.murata-ps.com/datasheet?http://www.murata-ps.com/data/power/ncl/kdc_mgj6-fb.pdf

MGJ6P – 3phase bridge : http://www.murata-ps.com/datasheet?http://www.murata-ps.com/data/power/ncl/kdc_mgj6-3p.pdf

MGJ6 – 14mm CR&CL: http://www.murata-ps.com/datasheet?http://www.murata-ps.com/data/power/ncl/kdc_mgj6-14mm.pdf

IGBT Applications – Design Wins



Electro Mobility



Water pump / flushing



Inverter for E-motor



Solar Inverter



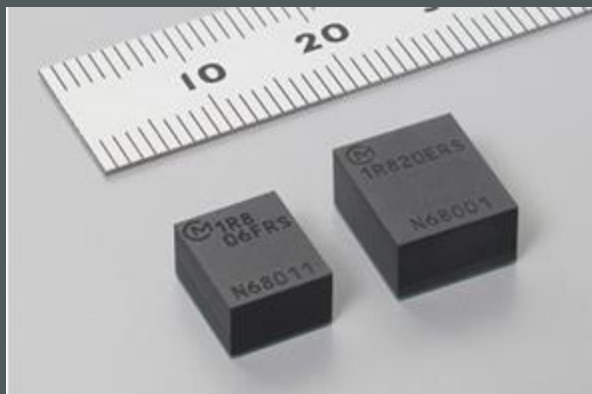
Welding machine



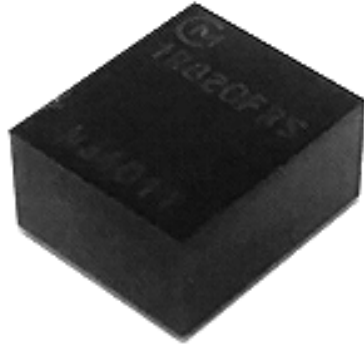
Inverter for E-motor

Non-isolated DC/DC

High Power Density MonoBlock



Structure & Features of MonoBlock Type POL



Advantage 1

Small & High Power Density

World smallest even with external components than any other power device including discrete designs.

Advantage 2

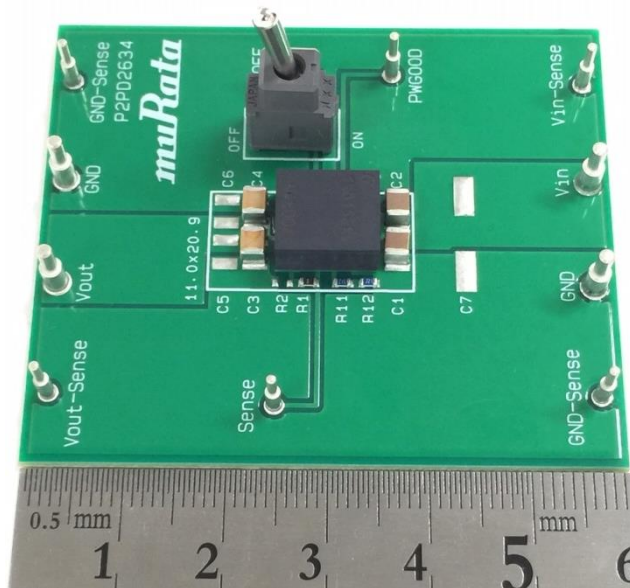
Fast Transient

Much faster with less external cap.
Best fit for FPGA/PLD application.

Advantage 3

Excellent Thermal Performance

Higher power de-rating capability at 95degreeC



Product Introduction(20A)

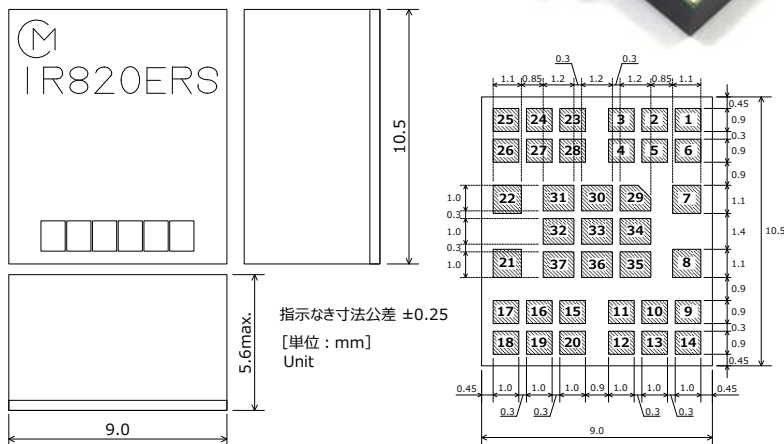
P/N : MYMGK1R820FRSR
MYMGK1R820ERSR

<http://power.murata.com/en/catalogsearch/result/?q=mym>

■ Feature

- Settable output voltage
- Up to 20 Amps of output current
- Quick response to load change
- Ultra small surface mount package
- High efficiency
- Outstanding thermal derating performance
- Over current protection
- On/Off control (Positive logic)
- Power Good signal

■ Appearance and Dimension

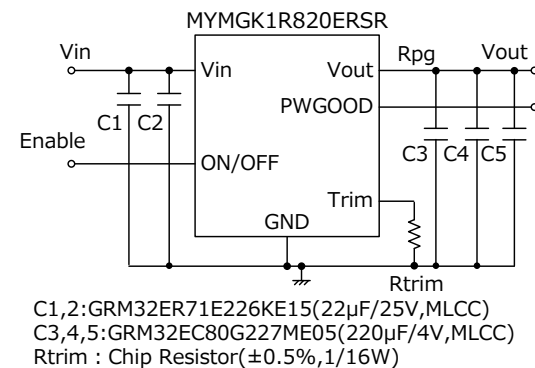


■ Specification

P/N	MYMGK1R820FRSR	MYMGK1R820ERSR
Vin[V]	4.5-5.5	8-14
Vo[V]	0.7-1.8	0.7-1.8
Io[A]	20	20
EFF[%]	89.2 (5Vin/1.8Vo)	87.8 (12Vin/1.8Vo)

■ Pin No. and Function

Pin No.	Name	Function
1 - 6	Vin	Input Voltage
7	PWGOOD	Power Good
8	ON/OFF	Enable
9 - 14	GND	GND
15 - 20	Vout	Output voltage
21	Sense	Output voltage Sense
22	Trim	Output voltage Adjustment
23 - 28	GND	GND
29 - 37	GND	Thermal PAD



Product Introduction(6A)

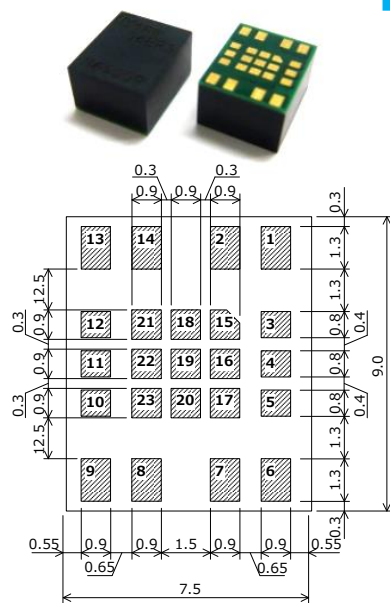
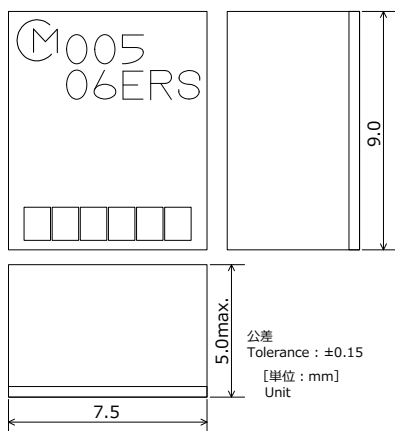
P/N : MYMGK1R806FRSR
MYMGK00506ERSR

<http://power.murata.com/en/catalogsearch/result/?q=mym>

■ Feature

- Settable output voltage
- Up to 6 Amps of output current
- Quick response to load change
- Ultra small surface mount package
- High efficiency
- Outstanding thermal derating performance
- Over current protection
- On/Off control (Positive logic)
- Power Good signal

■ Appearance and Dimension

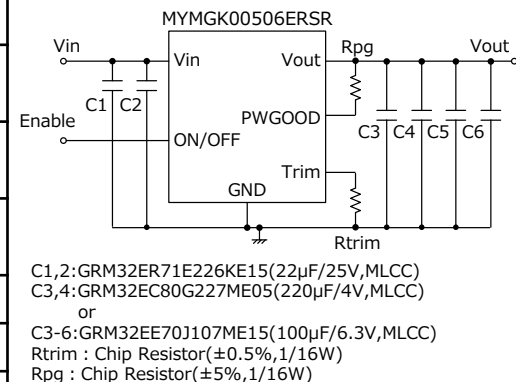


■ Specification

P/N	MYMGK1R806FRSR	MYMGK00506ERSR
Vin[V]	4.5-5.5	8-14
Vo[V]	0.7-1.8	0.7-5.0
Io[A]	6	6
EFF[%]	90.4 (5Vin/1.8Vo)	95.4 (12Vin/5.0Vo)

■ Pin No. and Function

Pin No.	Name	Function
1, 2	Vin	Input Voltage
3, 8, 9, 10, 13, 14	GND	GND
4	Trim	Output voltage Adjustment
5	Sense	Output voltage sense
6, 7	Vout	Output voltage
11	PWGOOD	Power Good
12	ON/OFF	Enable
15 - 23	GND	Thermal PAD



Product Introduction(2.5A)

P/N : MYLSM00502ERPL

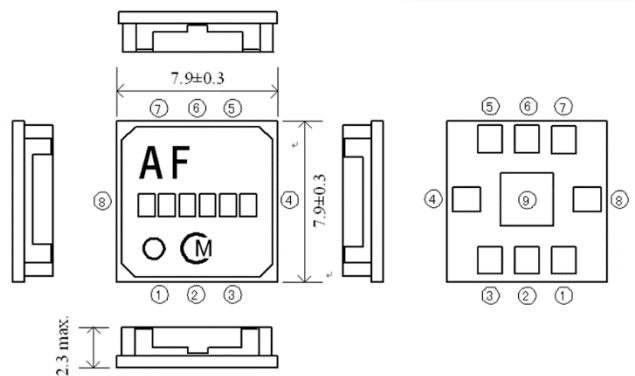
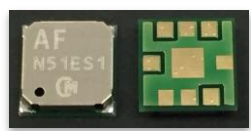
■ Feature

- Settable output voltage
- Up to 2.5 Amps of output current
- Quick response to load change
- Ultra small surface mount package
- Low profile (2.3mm Max.)
- High efficiency
- Over current protection
- On/Off control (Positive logic)

■ Specification

P/N	MYLSM00502ERPL
Vin[V]	4.5-17
Vo[V]	1.0-5.25
Io[A]	2.5
EFF[%]	89.4 (12Vin/5Vo)
Status	MP

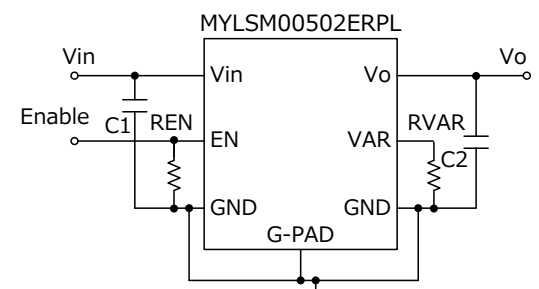
■ Appearance and Dimension



Product Mark : A F
Lot No. : 6 Alphanumeric

■ Pin No. and Function

Pin No.	Name	Function
1	VAR	Output voltage Adjustment
2	GND	GND
3		
4	Vin	Input Voltage
5	EN	Enable
6	GND	GND
7	Vo	Output voltage
8	GND	GND
9	G-PAD	GND pad for radiation



C1:GRM32DR71E106KA12(10μF/25V,MLCC)
C2:GRM31CC80J476KE18(47μF/6.3V,MLCC)
RVAR : Chip Resistor(±0.5%,1/16W)
REN : Chip Resistor(100k or Less,±0.5%,1/16W)

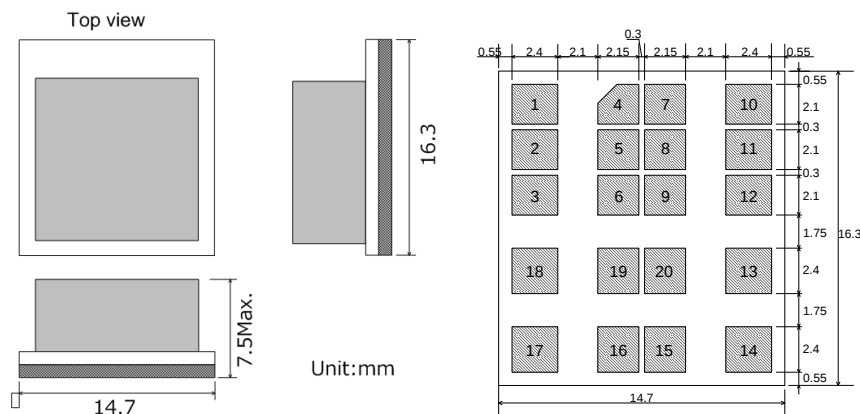
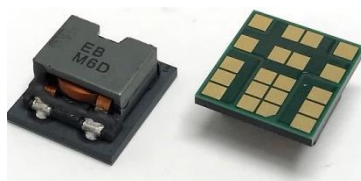
Product Introduction(40Vin)

P/N : MYSGK02506BRSR

■ Feature

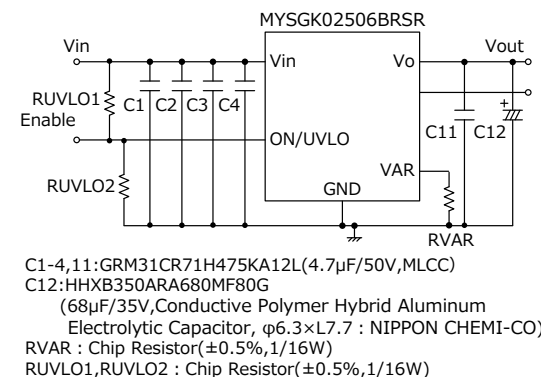
- Wide Input voltage
(Absolute maximum input voltage : 50Vdc)
- Settable output voltage
- High Efficiency
- Programmable UVLO
- Remote On/Off control
- Short Circuit Protection

■ Appearance and Dimension



■ Specification

Vin[V]	13.5-42
Vo[V]	5-25
Io[A]	6 (5A@Vin>36)
EFF[%]	98.0 (36Vin/24Vo)
Status	MP:Dec.'17

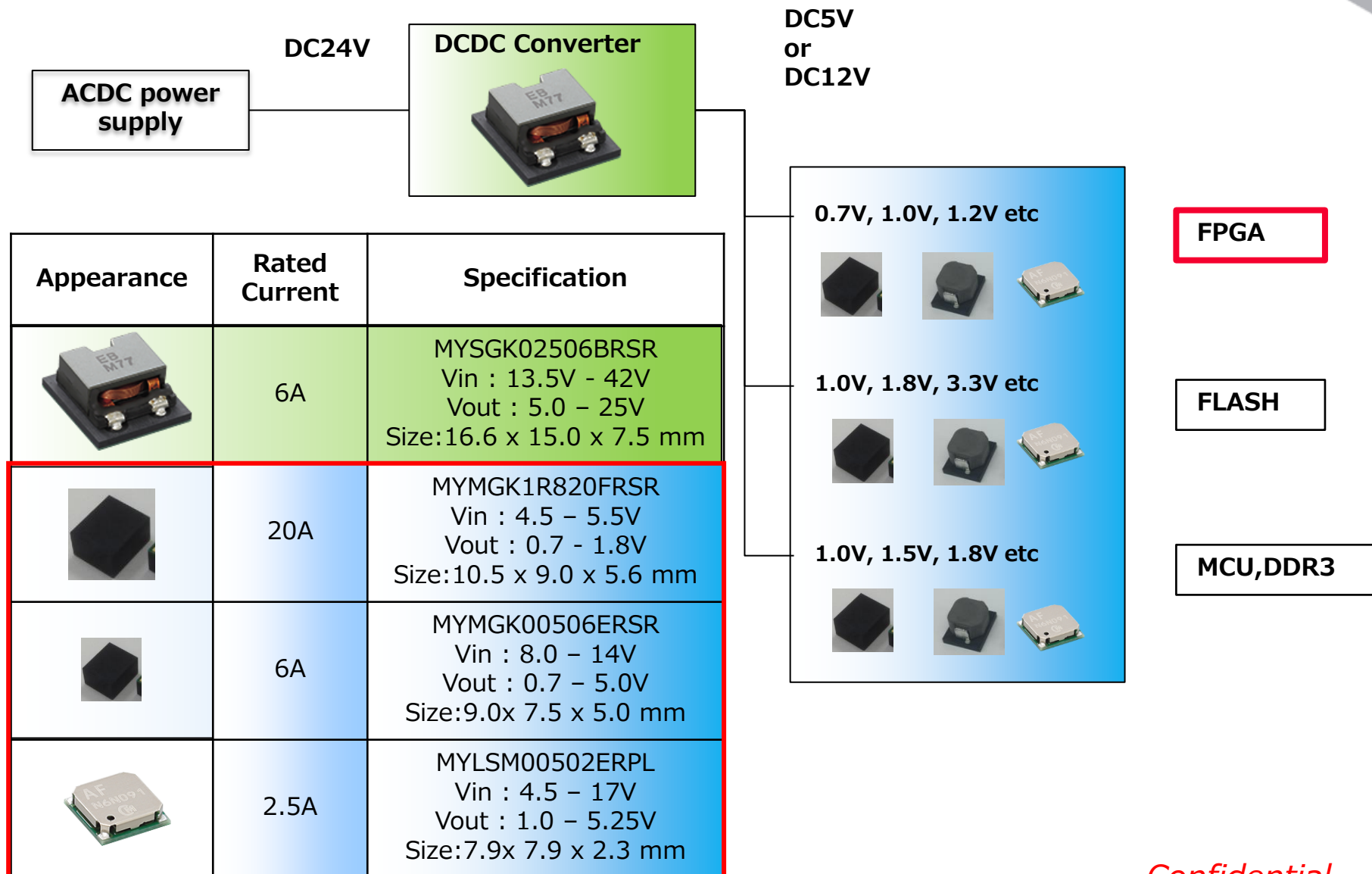


■ Pin No. and Function

Pin No.	Name	Function
1-3	Vin	Input Voltage
4-9	GND	GND
10-12	Vo	Output voltage
13	GND	GND
14	VAR	Output voltage Adjustment
15,16	GND	GND
17	EN/UVLO	Enable / UVLO
18-20	GND	GND

Block Diagram Example

Industrial & Medical Equipment



**Non-Isolated
PoL DC-DC
Okami**

OKL Series (DOSA SMT)

- Wide input voltage ranges: 4.5-14V (W12) & 2.4-5.5V (W5)
- Programmable outputs: up to 5.5V (W12) & up to 3.63V (W5)
- iLGA (Inspectable Land Grid Array)
- Industry Standard SMT footprint
- Over current, Output short circuit protection
- On/Off Control (Negative, Positive)
- Power Good Signal (for some models)
- Tracking/Sequencing option (OKL2 only)

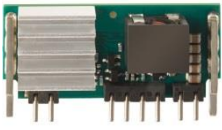
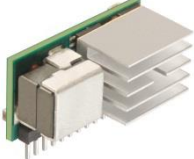


	DOSA 2 nd 12.2x12.2mm	DOSA 2 nd 12.2x12.2mm	DOSA 2 nd 12.2x12.2mm	DOSA 2 nd 20.3x11.4mm With Sync	DOSA 2 nd 33x 13.5mm With Sync	DOSA(with additional pin) 33x 13.5mm With Sync	GigaLynx Compatible 33x 22.9mm
4.5-14Vin (W12)	Wide Input 2.9-14Vin 	 OKL-T/3-W12*-C	 OKL-T/6-W12*-C	 OKL2-T/12-W12*-C	 OKL2-T/20-W12*-C	 OKL-T/25-W12*-C	 OKY2-T60-W12-C
2.4-5.5Vin (W5)	 OKL-T/1-W12*-C	 OKL-T/3-W5*-C	 OKL-T/6-W5*-C	 OKL-T/12-W5*-C	 OKL-T/20-W5*-C		
	1A	3A	6A	12A	20A	25A	60A

OKR Series (SIP)

- Wide input voltage ranges: 4.5-14V
- Programmable outputs: up to 5.5V, (50A: up to 2.5V)
- High Efficiency
- Over current, Over temperature protection
- On/Off Control (Positive)
- Industry Standard Footprint
- Single-Inline-Package (SIP)



4.5-14Vin (W12)	10.4x10.2x6.1mm	10.4x16.5x5.6mm	10.4x16.5x7.6mm	10.4x16.5x7.6mm	36.8x15.5x11.8mm	30.5x15.5x17.3mm	36.8x28x19.6mm
							
	OKR-T/1.5-W12-C	OKR-T/3-W12-C	OKR-T/6-W12-C	OKR-T/10-W12-C	OKR-T/20-W12-C	OKR-T/30-W12-C	OKR-T/50-W12-C
	1.5A	3A	6A	10A	20A	30A	50A

Rail & Transportation DC-DC Converters

IRx Series for 110V input



IRx Series for 110V input

Advantages

58 – 160VDC input voltage

Suitable for 110V applications

For Harsh environment

-40°C ... +110°C case operating temperature

EN 50155 & GB/T 25119 railway standards

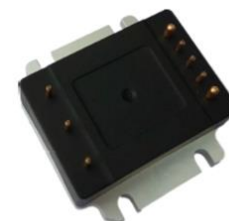
50m/s Shock & 30m/s Vibration

Encapsulated and Base plate

Great thermal conductivity

Less space needed

More power in a standard package



50W
1/16-brick



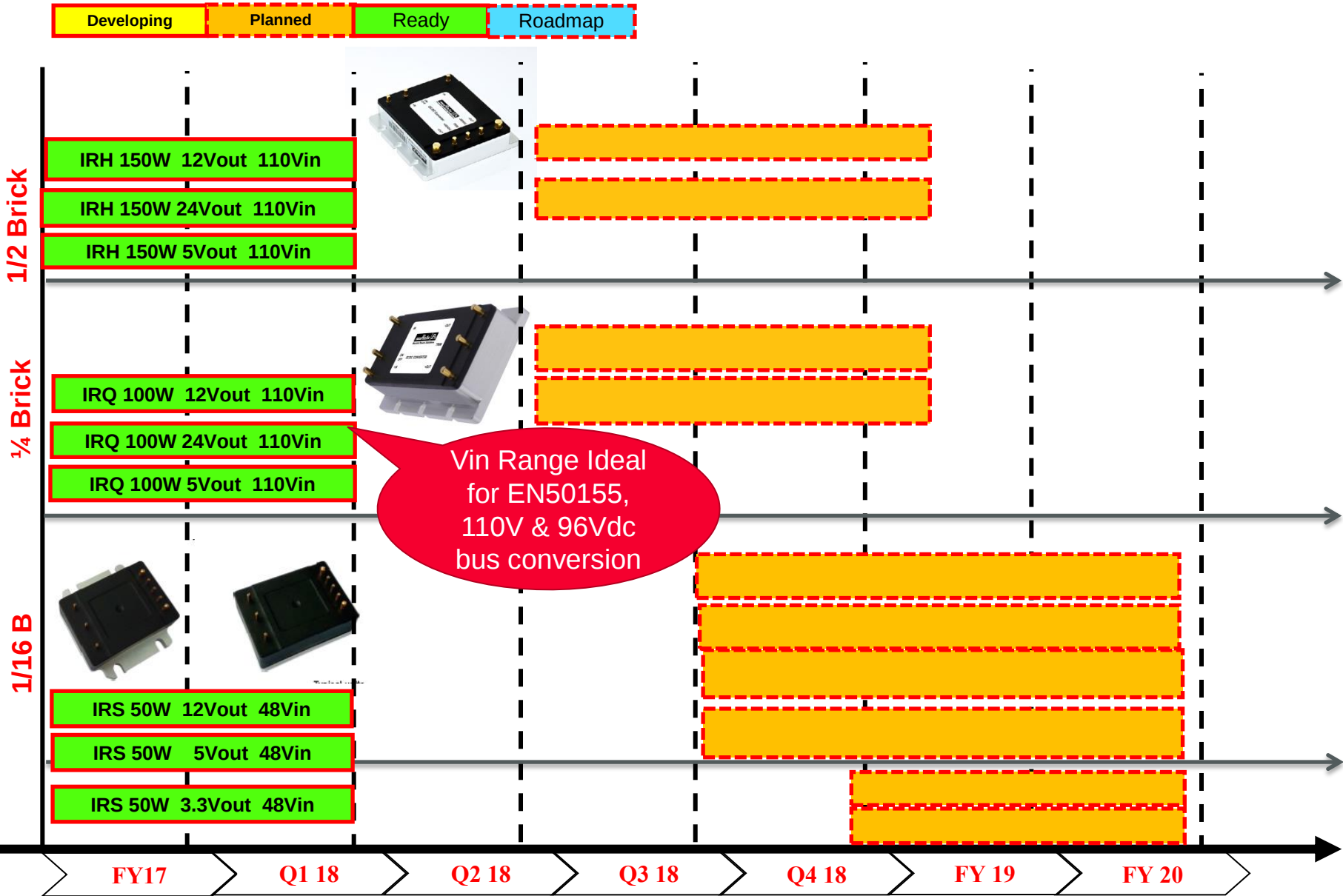
100W
1/4-brick



150W
1/2-brick

Industrial & Rail – Isolated DC/DC

58-160Vin Range (IRx Series)



IRH Series: 150W, Encapsulated, Half-Brick

IRH Series (up to 150W)

- Industrial Rail Half brick. Optimized for Rail.
- 3:1 Input voltage range: **57.6-160V** (T110)
- Half-brick footprint
- Slotted flanged baseplate
- Single output: **5V/30A, 12V/12.5A** or **24V/6.25A**
- High Efficiency – up to 91%
- 3000Vrms Reinforced isolation
- On/Off Control (Positive or Negative logic)
- Adjustable Output Trim ($\pm 10\%$)
- Thermal Shutdown Protection
- UL approval
- Designed to meet EN50155
- Railway and Industrial applications



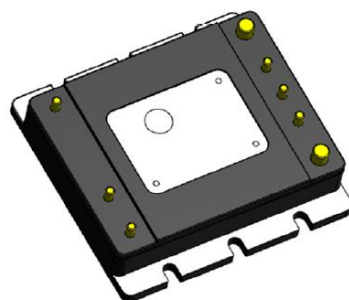
IRH Part Numbers



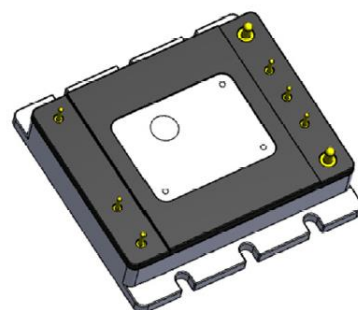
Part No.	Volts	Amps	Power
IRH-5-30-T110-PVF-C	5v	30A	150w
IRH-12-12.5-T110-PVF-C	12v	12.5A	150w
IRH-24-6.25-T110-PVF-C	24v	6.25A	150w

Above shows part no's - for positive logic, flanged baseplate, standard pin size. For other options see data sheet.

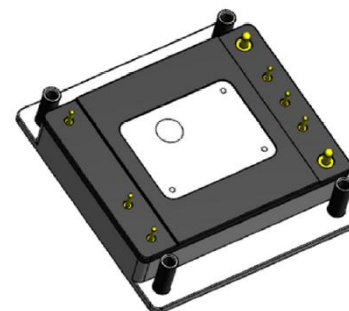
Package Options.



Slotted / Flanged Baseplate
"V" Option Pins / Pinout
Pin Diameter: 0.080 / 0.15



Slotted / Flanged Baseplate
DOSA Pins / Pinout
Pin Diameter: 0.040 / 0.080



Standard Baseplate
DOSA Pins / Pinout
Pin Diameter: 0.040 / 0.080

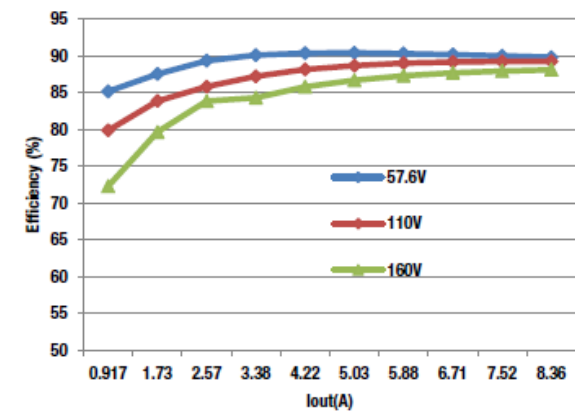
IRQ Series: 100W, Encapsulated Quarter-Brick

IRQ Series (up to 100W)

- Input voltage range: 57.6-160V (T110)
- Single output: **5V/20A, 12V/8.3A or 24V/4.2A**
- High Efficiency – up to 88% @ full load
- Quarter-brick footprint
- Two Industry Standard pinouts available
- Slotted flanged baseplate
- 3000Vdc Isolation, Reinforced I/O insulation
- On/Off Control (Positive or Negative logic)
- Adjustable Output Trim ($\pm 10\%$)
- Optional Remote Sense (DOSA version)
- Thermal Shutdown Protection
- UL safety approvals
- Designed to meet EN50155



PERFORMANCE DATA (IRQ-12/8.3-T110)



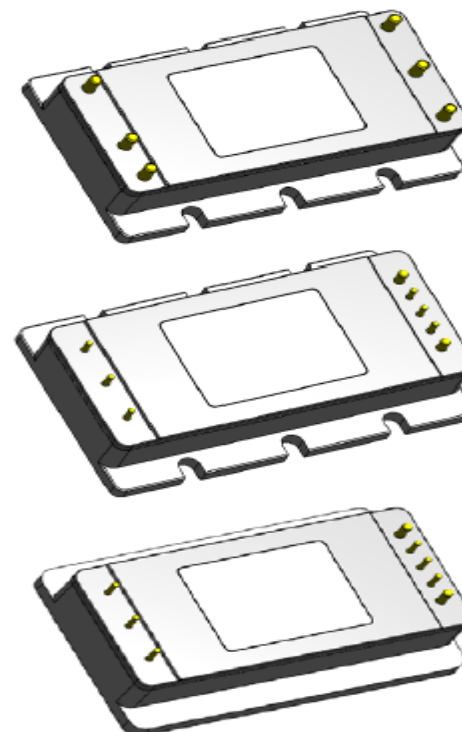
Efficiency vs. Load Current

Part No.	Volts	Amps	Power
IRQ-5-20-T110-PVF-C	5v	20A	100w
IRQ-12-8.3-T110-PVF-C	12v	8.3A	100w
IRH-24-4.2-T110-PVF-C	24v	4.2A	100w

Above shows part no's - for positive logic, flanged baseplate, standard pin size. For other options see data sheet.

Package Options.

- **1. Slotted / Flanged Baseplate**
 - “V” Option Pins / Pinout
 - Pin Diameter: 0.080”
- **2. Slotted / Flanged Baseplate**
 - DoSA Pins / Pinout
 - Pin Diameter: 0.040” / 0.060”
- **3. Standard Baseplate**
 - DoSA Pins / Pinout
 - Pin Diameter: 0.040” / 0.060”



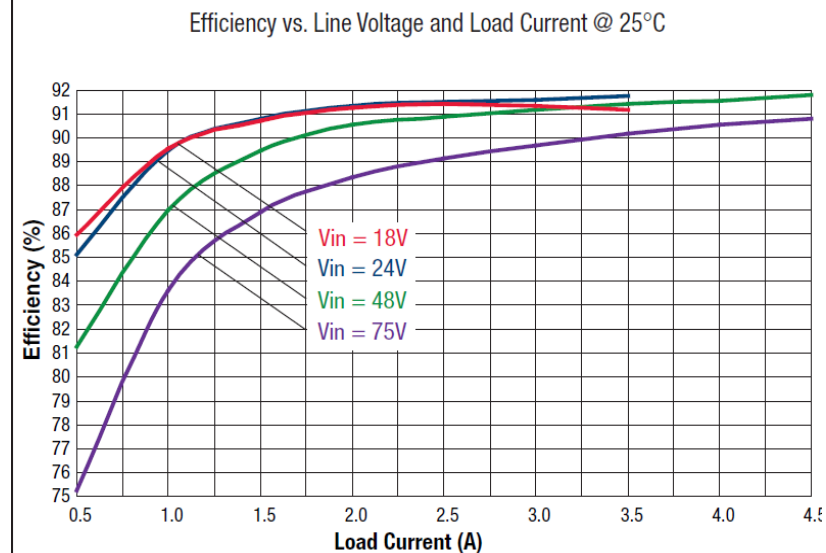
IRS Series: 50W, Encapsulated Quarter-Brick

IRS Series (up to 50W)

- Input voltage range: 9v – 36v / 18v – 75v
- Single output: **3v3/15A**, **5V/10A**, **12V/4.5A**, **15v/3.3A**, **24v/2.1A**.
- High Efficiency – up to 92% @ full load
- 1/16th brick footprint
- Two Baseplate options available – Standard/Flanged
- 3000Vdc Isolation, Reinforced I/O insulation
- On/Off Control (Positive or Negative logic)
- Adjustable Output Trim ($\pm 10\%$)
- Thermal Shutdown Protection
- UL safety approvals
- Designed to meet EN50155 24v / 48v systems.
- IRS Q12 – meet 12v / 24v battery systems.



TYPICAL PERFORMANCE DATA, IRS-12/4.5-Q48



IRS-Q12 Part Numbers

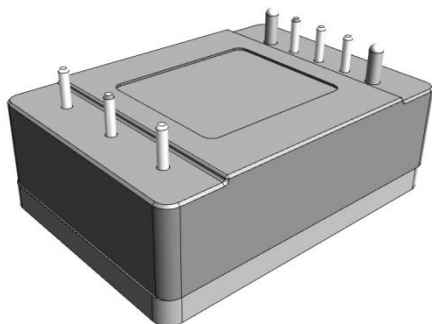


Part No.	Volts	Amps	Power
IRS-3.3/15- Q12PF-C	3v3	15A	50w
IRS-5/10-Q12PF-C	5v	10A	50w
IRS-12/4.5-Q12PF-C	12v	4.5A	50w
IRS-15/3-Q12PF-C	15v	3A	50w
IRS-24/2-Q12PF-C	24v	2A	50w

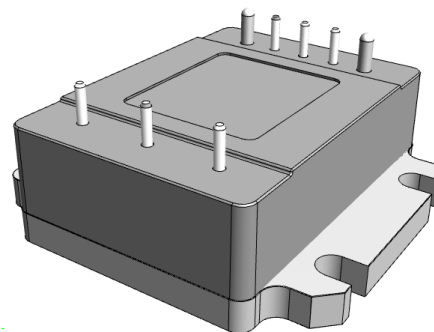
Above shows part no's - for positive logic, flanged baseplate, standard pin size. For other options see data sheet.

Package Options.

Standard Baseplate



Flanged Baseplate



IRS-Q48 Part Numbers

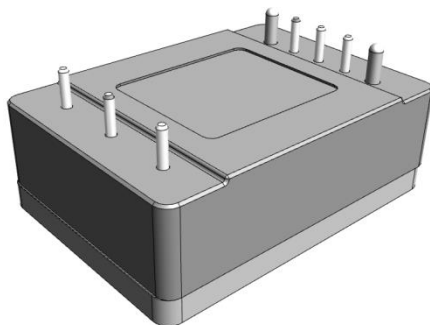


Part No.	Volts	Amps	Power
IRS-3.3/15- Q48PF-C	3v3	15A	50w
IRS-5/10-Q48PF-C	5v	10A	50w
IRS-12/4.5-Q48PF-C	12v	4.5A	50w

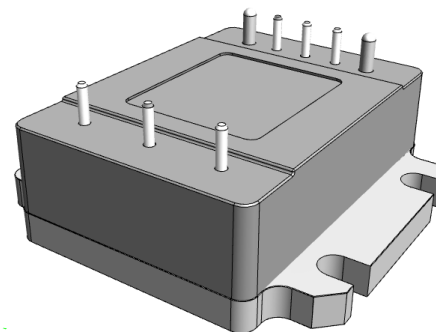
Above shows part no's - for positive logic, flanged baseplate, standard pin size. For other options see data sheet.

Package Options.

Standard Baseplate



Flanged Baseplate



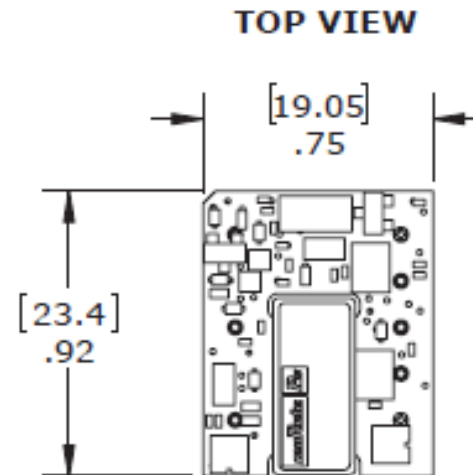
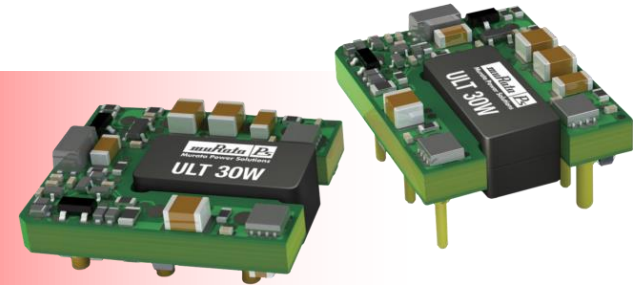
**2:1 - Telecommunications
Open Frame
Isolated DC-DC Converters**

2:1 Input - Thirty-Second Brick

ULT Series (up to 30W)

- 2:1 Input voltage range: 36-75V (D48)
- Thirty-second brick footprint
- 0.92" x 0.75" x 0.35" package
- Industry Standard – DOSA approved!
- Single 3.3V/7.5A, 5V/5A or 12V/2.5A output
- High Efficiency – up to 91%
- 1500Vdc input-to-output isolation
- Tight Line and Load Regulation
- On/Off Control (Positive or Negative logic)
- Adjustable Output Trim (-20%, +10%)
- Remote Sense
- Thermal Shutdown Protection
- UL approved
- Optional SMT Package
- Distributed Bus Applications

1/32 Brick
2:1 Input Range
Up to 30W



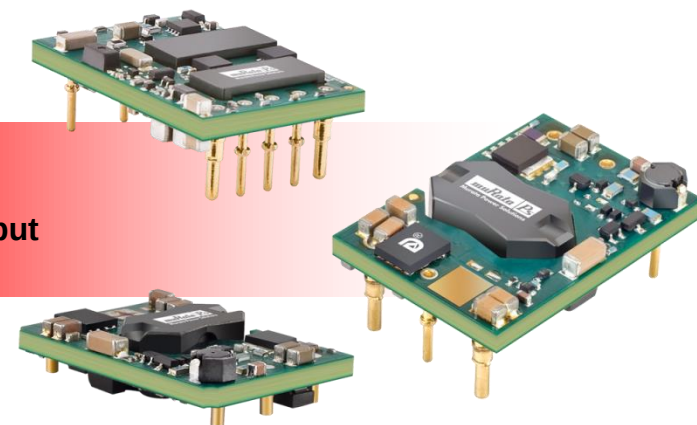
ULT
Series

2:1 Input – Sixteenth Bricks

ULS Series - 30W, 60W & 100W

- 2:1 input voltage range: 36-75V (D48)
- ULS-30W Series
Outputs: 3.3V/8A, 5V/6A, 12V/2.5A, 15V/2A
- ULS-60W Series
Outputs: 3.3V/20A, 5V/12A, 12V/5A
- ULS-100W Series
Outputs: 3.3V/30A, 5V/20A, 12V/8.3A
- Industry Standard 1/16th brick
- High efficiency – up to 92%
- 2250Vdc input-to-output isolation
- Through-hole & SMT versions
- Conformal coating optional
- Telecom & Industrial Applications

**1/16th Brick
Wide 2:1 Input**



ULS-
30W
Series

ULS-
60W
Series

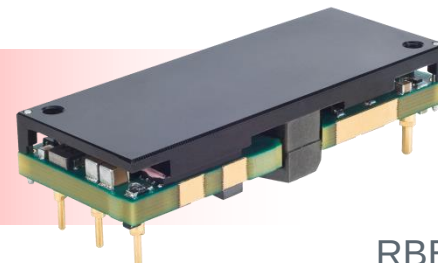
ULS-
100W
Series

2:1 Input - Eighth Bricks

RBE Series (240W)

- Regulated Bus Converter
- 2:1 Input voltage range: 36-75V (D48)
- Single output: 11.7V/20A
- High efficiency: 94.5%
- 2250Vdc input-to-output isolation
- Industry Standard 1/8th brick pinout
- Telecom & Wireless Applications

**1/8th Brick
Regulated Bus Converter**

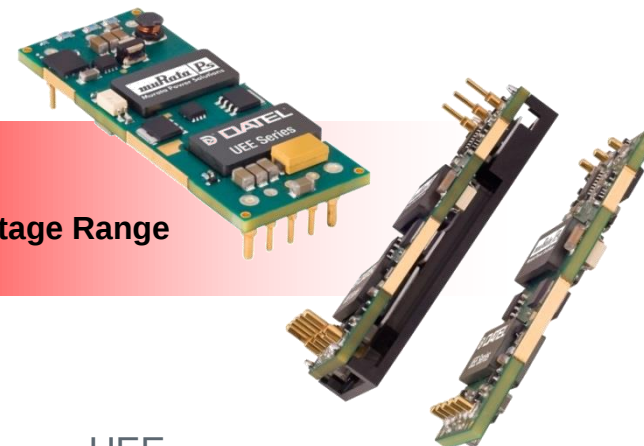


RBE
Series

UEE Series (up to 150W)

- 2:1 Input voltage range: 36-75V (D48)
- High Efficiency - 90% typ.
- Single Output: 3.3V at 15A/25A/30A
- Single Output: 5V at 10A/30A
- Single Output: 12V/12.5A
- Optional Base Plate
- 2250Vdc input-to-output isolation
- Industry Standard 1/8th brick pinout
- Through-hole & SMT versions
- Telecom Applications

**1/8th Brick
2:1 Input Voltage Range**



UEE
Series

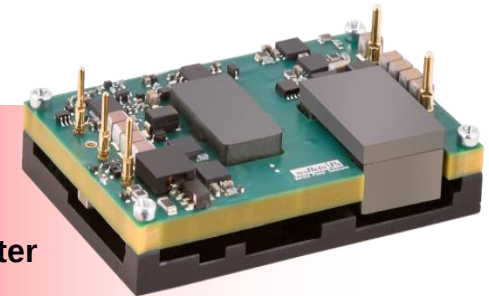
UEE
150W
Series

2:1 Input - Quarter Brick

HPQ Series (up to 300W)

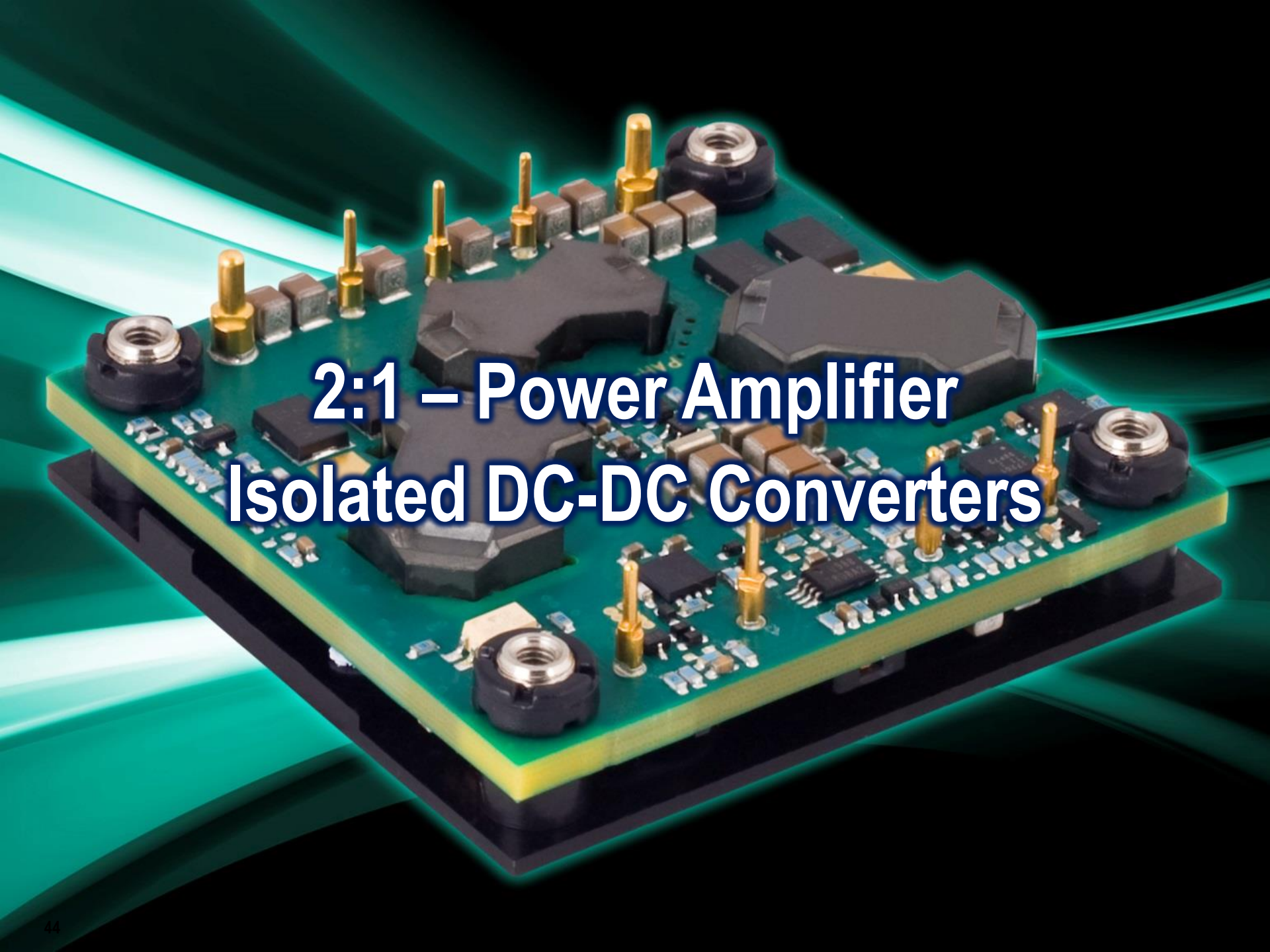
- 2:1 Input voltage range: 36-75V (D48)
- Industry standard 1/4 brick package
- DOSA pinout
- Optional baseplate
- High efficiency – up to 95%
- Single output: 3.3V/50A (HPQ-3.3/50-D48)
- Single output: 12V/25A (HPQ-12/25-D48)
- Available with or w/o Trim & Sense
- Tight line and load regulation
- 2250Vdc Input/Output isolation
- Telecom & Wireless Applications

**1/4 Brick
2:1 Input Range
Regulated Bus Converter**



HPQ-
3.3
Series

HPQ-
12
Series



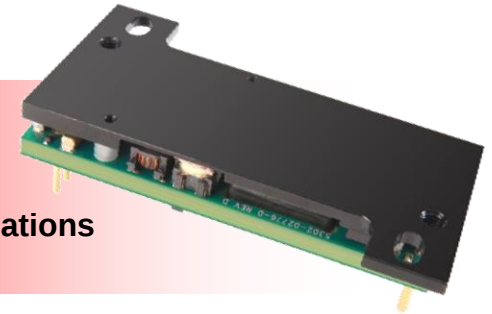
2:1 – Power Amplifier Isolated DC-DC Converters

2:1 Power Amplifier – Eighth & Quarter Bricks

PAE Series (100W)

- 2:1 Input voltage range: 36-75V (D48)
- High efficiency – up to 92% typ.
- Single output: 29.8V/3.3A
- Trimmable output from 23.84 to 32.78V
- 1500Vdc input-to-output isolation
- Optional Base Plate
- Industry Standard 1/8 brick
- Telecom & Wireless Applications

1/8 Brick
36-75V Input Range
Power Amplifier Applications

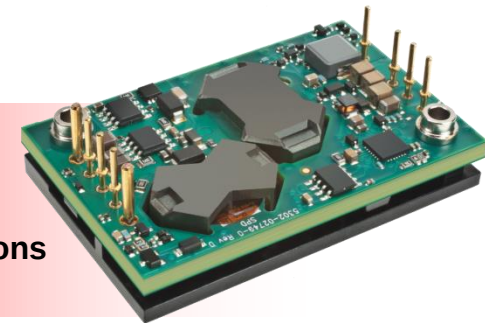


PAE
Series

PAQ Series (150W)

- 2:1 Input voltage range: 36-75V (D48)
- High efficiency – up to 92.5%
- Single 29.8V/5A output
- Trimmable output from 23.84 to 32.78V
- 2250Vdc input-to-output isolation
- Optional Base Plate
- Industry standard 1/4 brick
- Telecom & Wireless Applications

1/4 Brick
36-75V Input Range
Power Amplifier Applications



PAQ
Series

2:1 Power Amplifier - Half Bricks

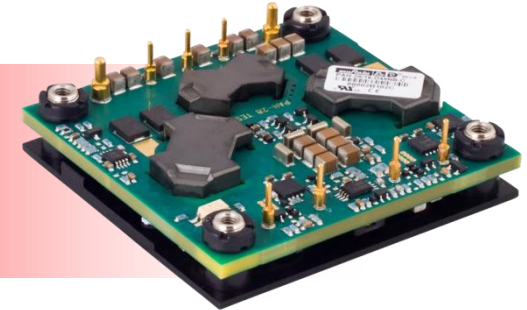
PAH Series (D48)

- 2:1 Input voltage range: 36-75V (D48)
- High Efficiency - 94% typ.
- Outputs: 28V/12.5A or 28V/16A
- Outputs: 48V/8.5A or 53V/8.5A
- Output adjustable from 16.8V to 32V
- 2250Vdc input-to-output isolation
- Optional Base Plate
- Industry standard ½ brick
- Power Amplifier, Wireless Applications

PAH Series (D24)

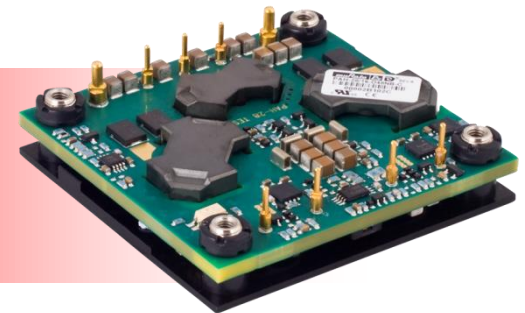
- 2:1 Input voltage range: 18-36V (D24)
- High Efficiency – 92.5% typ.
- Output: 28V/12.5A
- Output adjustable from 16.8V to 32V
- 2250Vdc input-to-output isolation
- Base Plate (standard)
- Industry standard ½ brick
- Power Amplifier, Wireless Applications

**1/2 Brick
36-75V Input Range
Power Amplifier**



PAH-28 PAH-53
Series Series

**1/2 Brick
18-36V Input Range
Power Amplifier**



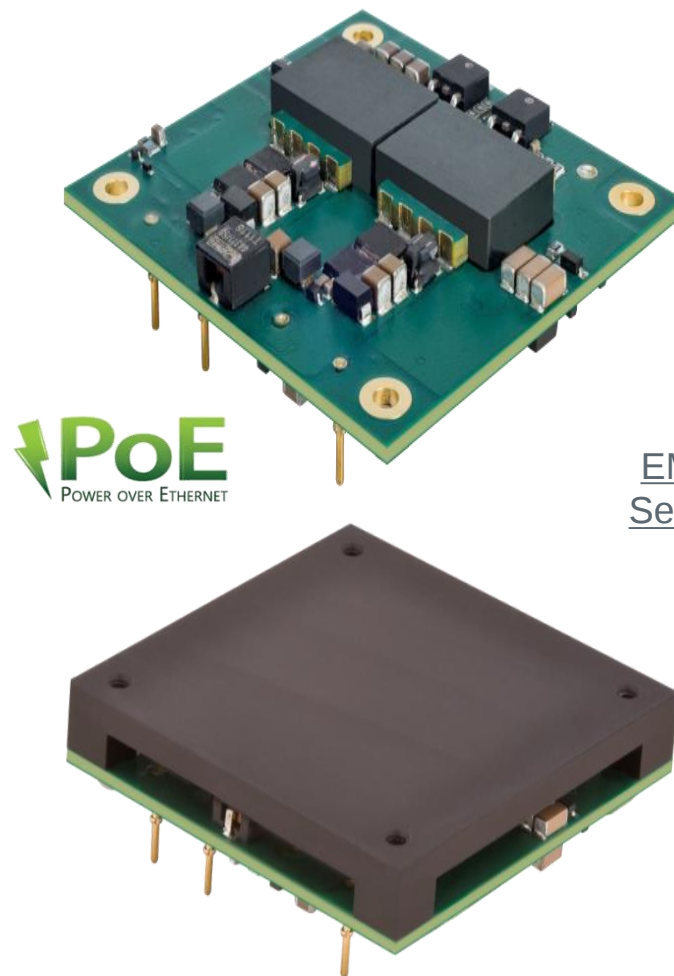
**Power over Ethernet
(PoE)
Isolated DC-DC Converters**

Features

- Input voltage range of 18-72V (48V nominal)
- Fixed output of 54V/3A (162W)
- Industry Standard Half-brick package
- Input-output isolation to 2250Vdc (Basic)
- Meets the requirements of IEEE 802.3 for PoE
- Tight line and load regulation
- High efficiency (91.5%, typical)
- On/Off control (Negative logic)
- Operating temperature range of -40°C to 85°C
- Certified to meet UL/EN 60950-1, CSA-C22.2 No. 60950-1, 2nd edition safety approvals

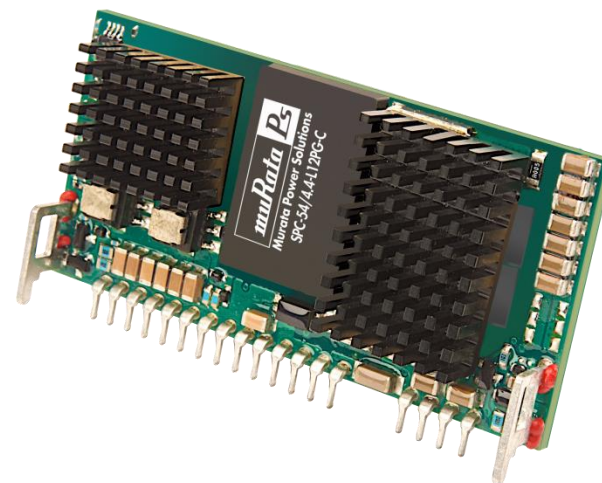
Options

- Baseplate (conduction cooling)
- 0.110" & 0.145" Pin lengths (L1 & L2 suffix)



Features

- Input voltage range of 11-13.2V (12V nominal)
- Fixed output of 54.2V/4.44A (240W)
- Single-Inline-Package (2.60" x 0.69" x 1.25")
- Input-output isolation to 2250Vdc (Basic)
- Meets the requirements of IEEE 802.3 for PoE
- Tight line and load regulation
- High efficiency (94%, typical)
- On/Off control (Positive logic)
- Operating temperature range of -40°C to 80°C
- Stable no-load output
- Thermal shutdown protection
- Power Good



[SPC](#)
[Data Sheet](#)

Isolated DC-DC converter for PD of PoE+ MYBSP0055AABF, MYBSP0122BABF

Feature

- Isolated DC-DC converter with function of IEEE802.3at hot-swap / detection / classification
- Powers up to 25.5W
- Size 22.4 x 35.5 x 10.55 mm typ
- Surface mount module
- Input-Output Isolation 2.25kVdc 1minute
- Operating Temperature range: -40C to +85C

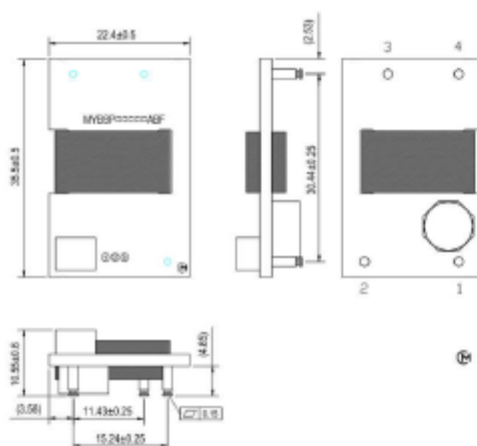
Function

- IEEE802.3at hot-swap, detection, classification
- Over Current Protection

Application

- IEEE802.3at's PD for PoE

Appearance



Pin assignment

Pin No.	Function
1	+Vin
2	-Vin
3	-Vout
4	+Vout

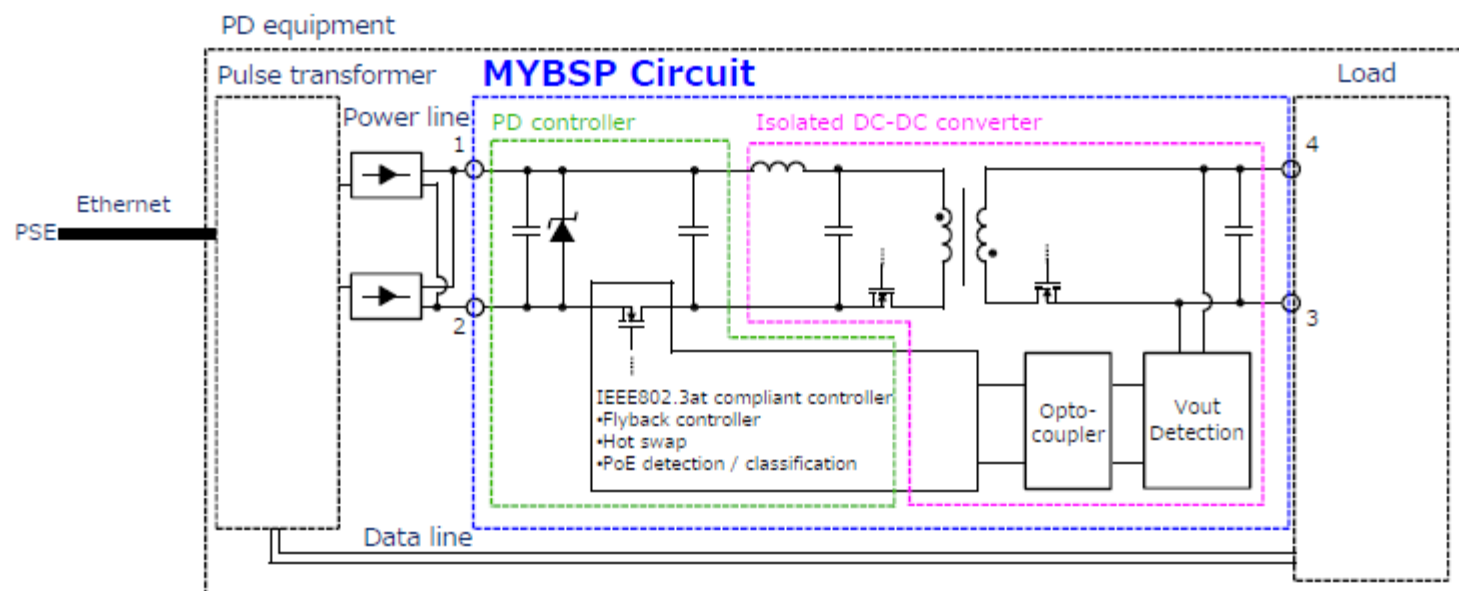
General Specifications

		MYBSP0055AABF	MYBSP0122BABF
Input	Typical Input Voltage	54V	
	Input Voltage Range	42.5 to 57V	
Output	Output Voltage	5V +3%	12V +3%
	Rated Output Current	0 to 5.1A	0 to 2.125A
	Over Current Protection (min.)	5.3A	2.2A
	Efficiency (typ.)	90.5%	92.5%
	Output Ripple and Noise (Max.)	150mV	150mV
Isolation	Input-Output (min.)	2.25kVdc 1minute	
Environmental	Operating Condition	-40 to 85C, 20 to 85%RH, No dew	
	Storage Condition	-45 to 90C, 10 to 95%RH, No dew	

Confidential

Isolated DC-DC converter for PD of PoE+ MYBSP0055AABF, MYBSP0122BABF

Block Diagram



Confidential

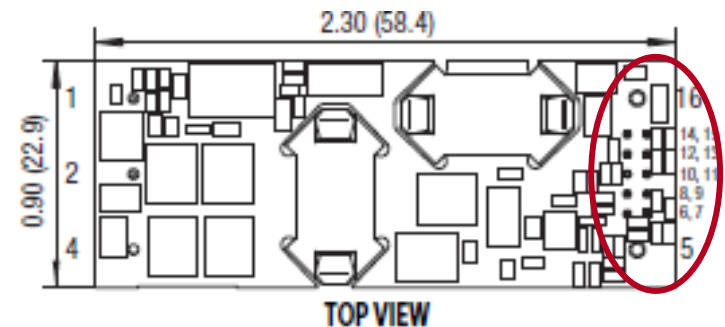
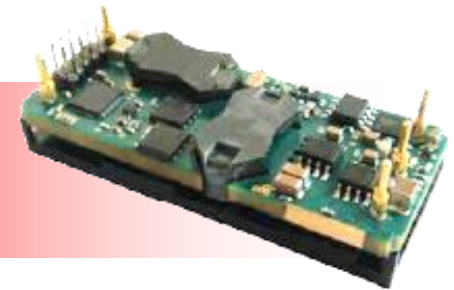
**2:1 – Digitally Controlled
Isolated DC-DC Converters**

300W Digital Controlled - Eighth Brick

DBE & DVE Series

- Fully regulated intermediate bus converter
- Digital PMBus interface
- Advanced Bus Converter (ABC) footprint
- Industry standard five pin Eighth-brick
- 2:1 Input voltage range: 36-75V
- High efficiency, typ. 95% at half load
- Single outputs: 12V/25A, 5V/40A, 3.3V/40A
- 2250Vdc isolation Input-to-Output
- Optional baseplate
- Configurable soft start/stop
- Precision delay and ramp-up
- Voltage sequencing and margining
- Voltage/current/temperature monitoring
- Wide output voltage range
- Telecom and Wireless Applications

**1/8 Brick
Digital Control**



DBE
Series



420W Digital Controlled - Quarter Brick

DBQ Series (420W)

- Fully regulated intermediate bus converter
- Digital PMBus interface
- Advanced Bus Converter (ABC) footprint
- Optional five pin DOSA footprint (w/o PMBus)
- 2:1 Input voltage range: 36-75V
- 12V/35A nominal output
- Configurable output from 8.1Vdc to 13.2Vdc
- 2250Vdc input to output isolation
- Efficiency 96% typical
- Negative or Positive Logic On/Off control
- Monotonic startup into pre-bias output conditions
- Open-frame or optional baseplate version
- Optional load sharing for parallel operation
- Operational Temperature Range -40°C to $+85^{\circ}\text{C}$
- Telecom and Wireless Applications

**1/4 Brick
Digital Control**



TOP VIEW

DBQ
Series

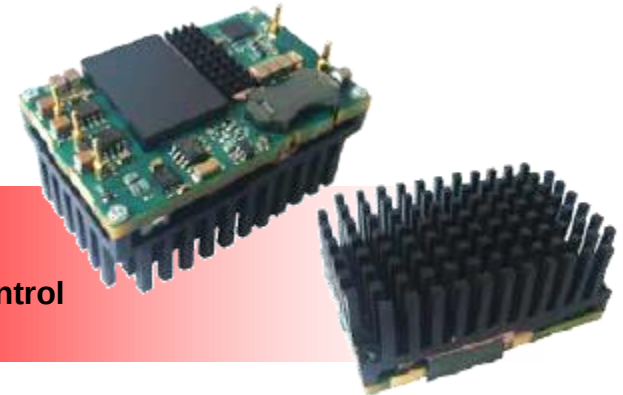


500W Digital Controlled - Quarter Brick

DRQ Series (500W)

- Fully regulated intermediate bus converter
- Digital PMBus interface
- Advanced Bus Converter (ABC) footprint
- Optional five pin DOSA footprint (w/o PMBus)
- 2:1 Input voltage range: 38-75V
- 11.5V/43.5A nominal output
- 2250Vdc input to output isolation
- Efficiency 96% typical
- Negative or Positive Logic On/Off control
- Monotonic startup into pre-bias output conditions
- Optional baseplate or integrated heat sink
- Operational Temperature Range -40°C to $+85^{\circ}\text{C}$
- Telecom and Wireless Applications

**1/4 Brick
Digital Control**



TOP VIEW

DRQ
Series

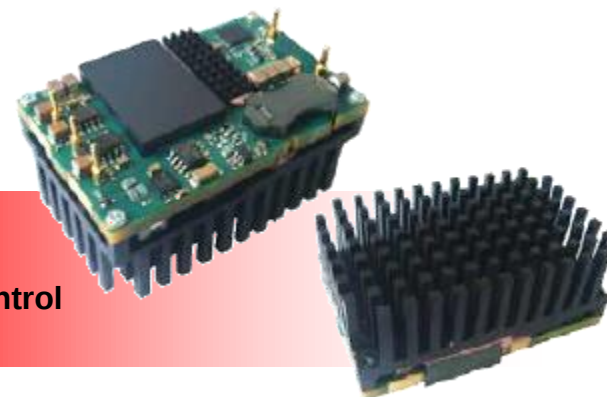


600W Digital Controlled - Quarter Brick

DRQ Series (600W)

- Fully regulated intermediate bus converter
- Digital PMBus interface
- Advanced Bus Converter (ABC) footprint
- Optional five pin DOSA footprint (w/o PMBus)
- 2:1 Input voltage range: 44-60V
- 12V/50A nominal output
- 2250Vdc input to output isolation
- Efficiency 96% typical
- Negative or Positive Logic On/Off control
- Monotonic startup into pre-bias output conditions
- Optional baseplate or integrated heat sink
- Optional load sharing for parallel operation
- Operational Temperature Range -40°C to $+85^{\circ}\text{C}$
- Telecom and Wireless Applications

**1/4 Brick
Digital Control**



TOP VIEW

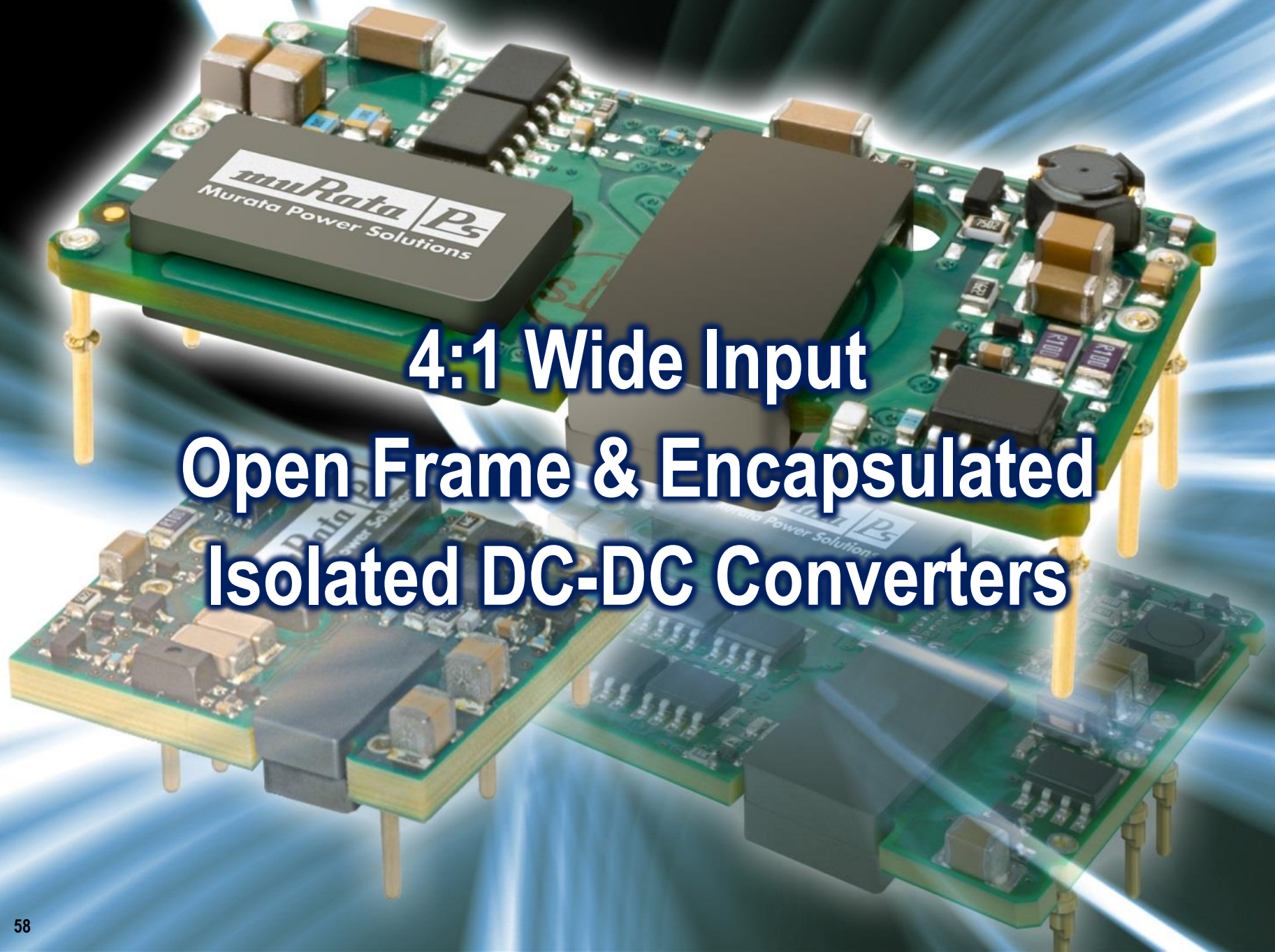
DRQ
Series



1000W Digital Controlled - Quarter Brick

- The fully regulated DRQ-11.4/88-L48xx Series provides 11.4Vout at 88 A, with a Vin Range of 36 to 60Vdc, operating from 48Vdc battery systems or networking equipment that operates at 54Vin. This fully regulated, fixed frequency, 1 kW rated bus converter boasts an industry leading efficiency level of 97%.
- standard DOSA high power 1/4 brick specification, parallel load sharing of two or more modules, pre-bias protection, positive or negative on/off logic options, short circuit protection, over current/voltage and over temperature protection. Supports pre-biased start-up, eliminating reverse current issues during system start and shutdown.
- fully isolated modules provide 1,500 Vdc of Input / Output isolation with an operational insulation safety rating. Designed and tested to meet the industry requirements of IPC-9592 Revision B. The converters' integrated baseplate design enhances thermal performance and its 97% efficiency promotes cooler operation for reliability and longevity.
- The primary applications for Murata's DRQ-11.4/88-L48 are networking and telecommunications infrastructure equipment, communications equipment, network security, routers, wireless base stations, telecommunications switches and electronics, computing equipment and other applications requiring power conversion to an intermediate bus voltage of 11.4 V.





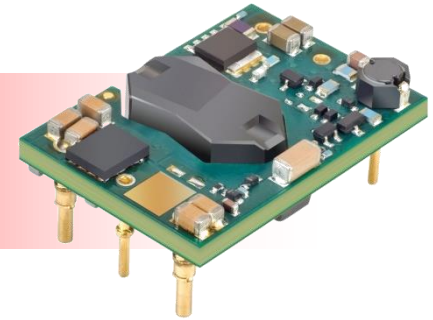
4:1 Wide Input Open Frame & Encapsulated Isolated DC-DC Converters

4:1 Input – Sixteenth and Eighth Bricks

UWS Series (up to 54W)

- 4:1 input voltage range: 18-75V (Q48)
- High efficiency – up to 91%
- Single outputs: 3.3V/15A, 5V/10A & 12V/4.5A
- Industry Standard 1/16th brick pinout
- Through-hole & SMT versions
- 2250Vdc input-to-output isolation
- Telecom & Wireless Applications

1/16th Brick
4:1 Input Voltage Range

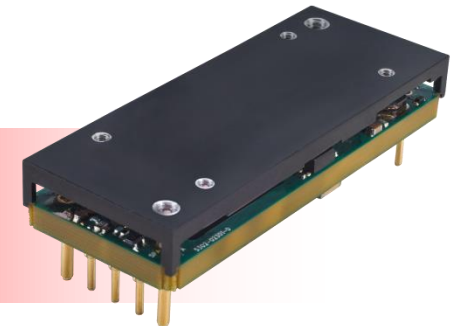


UWS
Series

UWE Series (up to 120W)

- 4:1 input: 9-36V (Q12), 18-75V (Q48)
- High efficiency – up to 93% typ.
- Single outputs: 3.3V/30A, 5V/20A, & 12V/10A
- Higher power than our UWE models (75W)
- Optional Base Plate
- Industry Standard 1/8th brick
- 2250Vdc input-to-output isolation
- Telecom & Wireless Applications

1/8th Brick
4:1 Input Voltage Range



UWE
Series

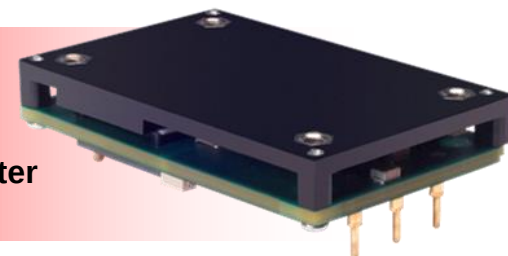
UWE-
100W
Series

4:1 Input - Quarter Bricks

UWQ-T48 Series (240W)

- Regulated Bus Converter
- Input voltage range: 18-60V (T48)
- High efficiency – up to 92% typ.
- Single output: 12V/20A
- Optional Base Plate
- Industry Standard 1/4 brick
- Telecom & Wireless Applications

1/4 Brick
18-60V Input Range
Regulated Bus Converter

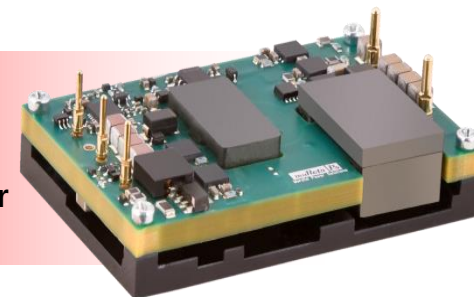


UWQ-T48
Series

UWQ Series (204W)

- Regulated Bus Converter
- 4:1 input voltage range: 18-75V (Q48)
- High efficiency – up to 95%
- Single 12V/17A output
- Industry standard 1/4 brick
- Optional Current Sharing (S)
- New Trim & Sense version (UWQ-T)
- Telecom & Wireless Applications

1/4 Brick
18-75V Input Range
Regulated Bus Converter



UWQ
Series

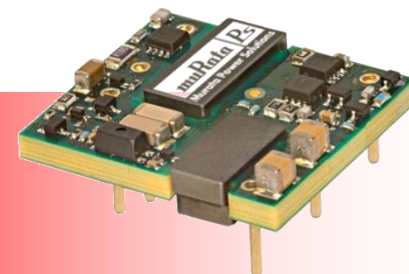
UWQ-T
Series

4:1 & 2:1 Input - Open Frame Module

UEI15 Series (15W)

- Two ultra-wide 4:1 input ranges: 9-36V (Q12) or 18-75V (Q48)
- Small footprint maintains industry standard pinout
- High input-to-output isolation
- SMT option available
- Drop-in replacement for typical 1" x 2" modules
- Single outputs from 3.3V to 15Vout
- Telco, Industrial, Medical & Rail Applications

1"x 1"
4:1 Input
Single Output

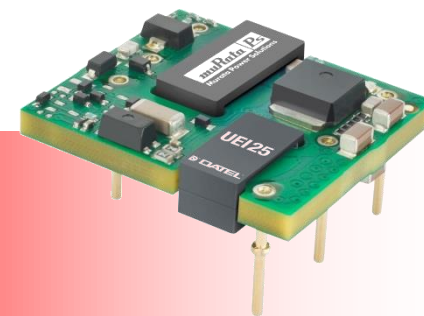


UEI15
Series

UEI25 Series (25W)

- Wide 2:1 input ranges: 36-75V (D48)
- Small footprint maintains industry standard pinout
- High input-to-output isolation
- SMT option available
- Drop-in replacement for typical 1" x 2" modules
- Single 3.3V, 5V and 12V output
- Telco, Industrial, Medical & Rail Applications

1"x 1"
2:1 Input
Single Output

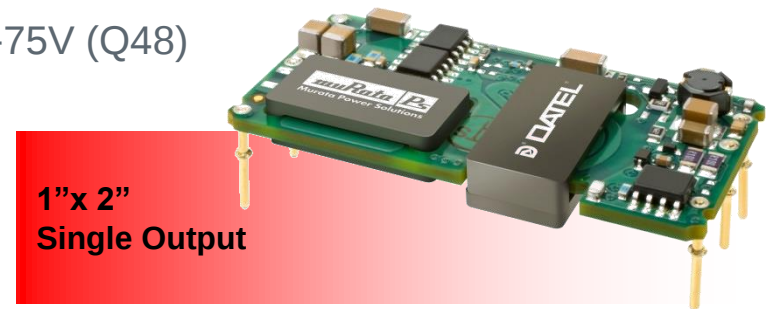


UEI25
Series

4:1 Input - Open Frame Module

UEI30 Series (30W)

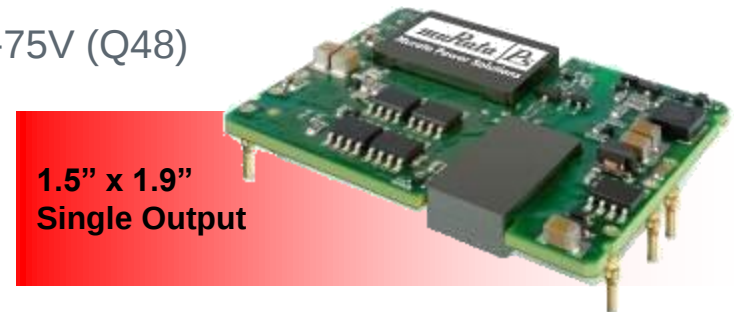
- Two ultra-wide 4:1 input ranges: 9-36V (Q12) or 18-75V (Q48)
- Small footprint maintains industry standard pinout
- Drop-in replacement for typical 1"x 2" modules
- Single outputs from 3.3V to 15V_{out}
- High input-to-output isolation
- Telco, Industrial, Medical & Rail Applications



UEI30
Series

UEI Series (50-60W)

- Two ultra-wide 4:1 input ranges: 9-36V (Q12) or 18-75V (Q48)
- Small footprint maintains industry standard pinout
- Drop-in replacement for typical 2" x 2" modules
- Single outputs from 3.3V to 15V_{out}
- High input-to-output isolation
- Telco, Industrial, Medical & Rail Applications



UEI 50-60W
Series

4:1 Input - Open Frame Module

BEI15 Series (15W)

- Two ultra-wide 4:1 input ranges: 9-36V (Q12) or 18-75V (Q48)
- Small footprint maintains industry standard pinout
- Drop-in replacement for typical 1" x 2" modules
- Dual bipolar outputs ($\pm 5V$, $\pm 12V$ or $\pm 15V$)
- High input-to-output isolation
- Telco, Industrial, Medical & Rail Applications

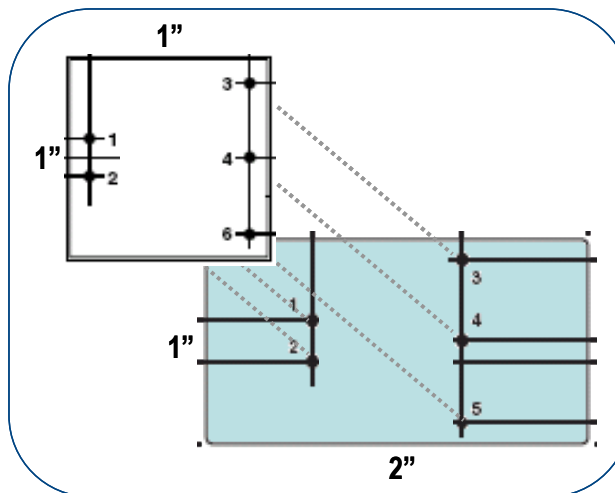
1"x1"
Bipolar Outputs



"Inside" footprint

pin compatible with:

- 1"x 1" package
- 1"x 2" package



BEI15
Series

4:1 & 2:1 Input - Encapsulated Module

SPM15 Series (15W)

- 4:1 Input : 9-36V (Q12) 18-75V (Q48)
- 1" x 1" Encapsulated package
- Industry Standard footprint
- 5 sided shielded metal package
- Single outputs of 3.3V, 5V and 12V
- 1600Vdc Isolation (Input-to-Output)
- Industrial and transportation applications

1"x 1"
4:1 Input Range
Single Output



SPM15
Series

SPM25 Series (25W)

- 2:1 Input: 36-75V (D48)
- 1" x 1" Encapsulated package
- Industry Standard footprint
- 5 sided shielded metal package
- Single outputs of 3.3V, 5V and 12V
- 1600Vdc Isolation (Input-to-Output)
- Industrial and transportation applications

1"x 1"
2:1 Input Range
Single Output



SPM25
Series

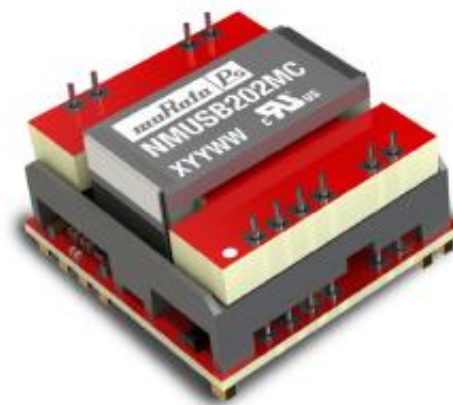
Latest Low Power DCDC

March 2018



NMUSB202MPC

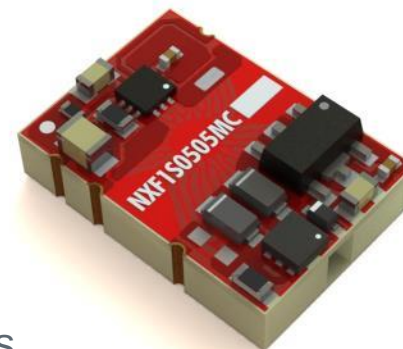
- Isolated Dual Powered USB 2.0 Compliant interface
- One upstream port, 2 isolated downstream ports
- Automatic switching between low (1.5Mbps) and full speed (12Mbps)
- Full 500mA available from each isolated port
- UL60950 recognition pending
 - Reinforced insulation to a working voltage of 250VAC
- Medical recognition ANSI/AAMI ES60601-1 pending
 - **2 MOPP/2 MOOPs**, 250VAC
- Short circuit/overload protected USB ports
- Power Surge Notification
- Patents pending
- Industrial operating temperature range -40°C to 85°C



Estimated Launch Date: Q1-2018

NXF1 Product Specification

- **Fully Regulated output, 1W Design**
 - Input voltages of 3.3V and 5V
 - Output voltages of 3.3V and 5V
- 3.3kVDC isolation 'Hi Pot Test'
- UL60950 Certification pending
 - Reinforced insulation to a working voltage of 125Vrms
- ANSI/AAMI ES60601-1 pending for 2MOOP, 1MOPP
- Operating temperature range -40°C to +105°C for 5V input and -40°C to +90°C for 3.3V inputs.
- Typical line regulation of 0.03% for 3.3V and 0.01% for 5V.
- Typical load regulation of 0.5% for 3.3V and 0.4% for 5V.
- SMD Package



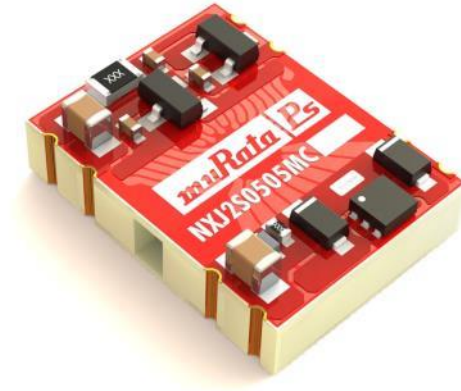
Cross Reference

	Recom	Recom	XP	Cui
NXF1S0303MC	R1Z033.3	R1Z033.3/H		
NXF1S0305MC	R1Z0305	R1Z0305/H		
NXF1S0505MC	R1Z0505	R1Z0505/H	ISG0505A	PQM1-S5-S5-M

Launched March 2018

NXJ2 Product Specification

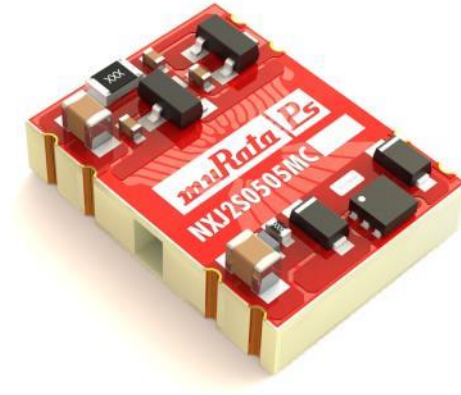
- Un-Regulated 2W Design
 - Input voltages of 5V, 12V and 24V
 - Output voltages of 5V, 12V and 15V
- 5.2kVDC isolation 'Hi Pot Test'
- UL60950 recognition pending
 - Reinforced insulation to a working voltage of 250Vrms
- ANSI/AAMI ES60601-1 pending for 2MOOP, 1MOPP
- Operating temperature range -40°C with derating to +95°C
- SMD Package



Estimated Launch Date: Q1-2018

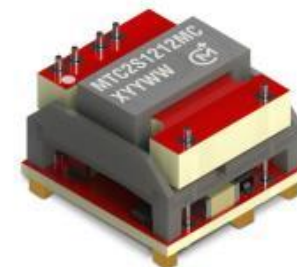
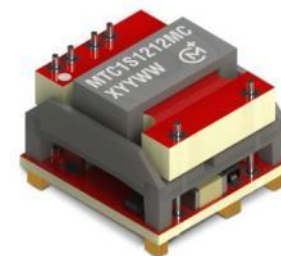
NXJ2 Competitor Advantages

- Lower Profile
- Smaller footprint
- Higher Isolation test voltage
- 260°C reflow temperature as per J-STD-020
- Higher level of insulation with reinforced insulation
- Medical recognition pending
- Halogen Free



MTC1 & MTC2 Range Extension

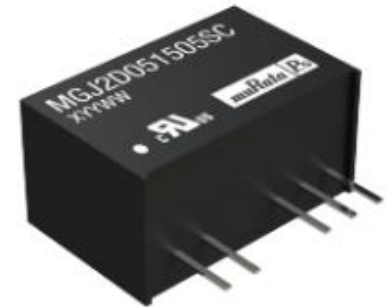
- Fully Regulated output
 - 2:1 input ranges of **4.5-9V**, 9-18V and 18-36V
 - 3kVAC isolation test voltage 'Hi Pot Test'
 - Outputs of 3.3V, 5V, and 12V at 1W & 2W
- UL60950 Recognition pending
 - Reinforced insulation to a working voltage of 250Vrms
- ANSI/AAMI ES60601-1, 2 MOOP 1 MOPP pending
- -40°C to +100°C operating temperature range
 - Wide industrial temperature range
 - Full power to 85°C (model-dependent), convection cooled
- SMD Package
 - Smaller footprint than currently available solutions with the same insulation grade
- Output on/off control pin
- Output Voltage Adjustment
- Continuous Short Circuit Protection



Estimated Launch Date: End 2018

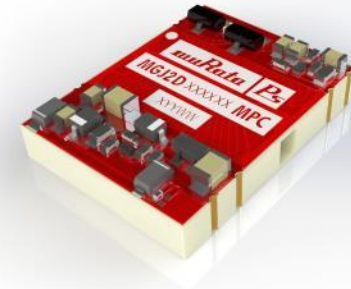
MGJ2 Range Extension

- 2W Through hole gate drive DC/DC converters
 - 5V, 12V, 15V & 24V inputs
 - +15V/-15V, +15V/-5V, +15V/-8.7V & +20V/-5V outputs
 - **New +20/-3.5V output added**
 - **New +18V/-2.5 in development**
- DC link voltage 1.5kVDC
- Optimised bipolar output voltages for IGBT/Mosfet gate drives
- UL60950 recognised
 - Reinforced insulation to a working voltage of 150Vrms
 - Basic/Supplementary insulation to a working voltage of 300Vrms
- ANSI/AAMI ES60601-1, 1 MOPP/2 MOOPs
- 5.2kVDC isolation test voltage 'Hi Pot Test'
- -40°C to +100°C operating temperature range



MGJ2 Product Specification

- Optimised bipolar output voltages for IGBT, SiC & MOSFET gate drives
 - +15V/-5V, +15V/-9V and +20V/-5V.
- Four input voltages of 5V, 12V, 15V and 24V
- High isolation tested at 5.7kV, rated for continuous operation to 3kV
- UL62368-1 recognition pending
 - Reinforced insulation to a working voltage of 300VAC
- EN618900-5 recognition pending
 - Reinforced insulation to a working voltage of 300VAC
- Low barrier capacitance (5pF typ)
- -40°C to +105°C operating temperature range
- Characterized partial discharge performance pending
- SMD package
 - 17.5mm*14.5mm*3.1mm

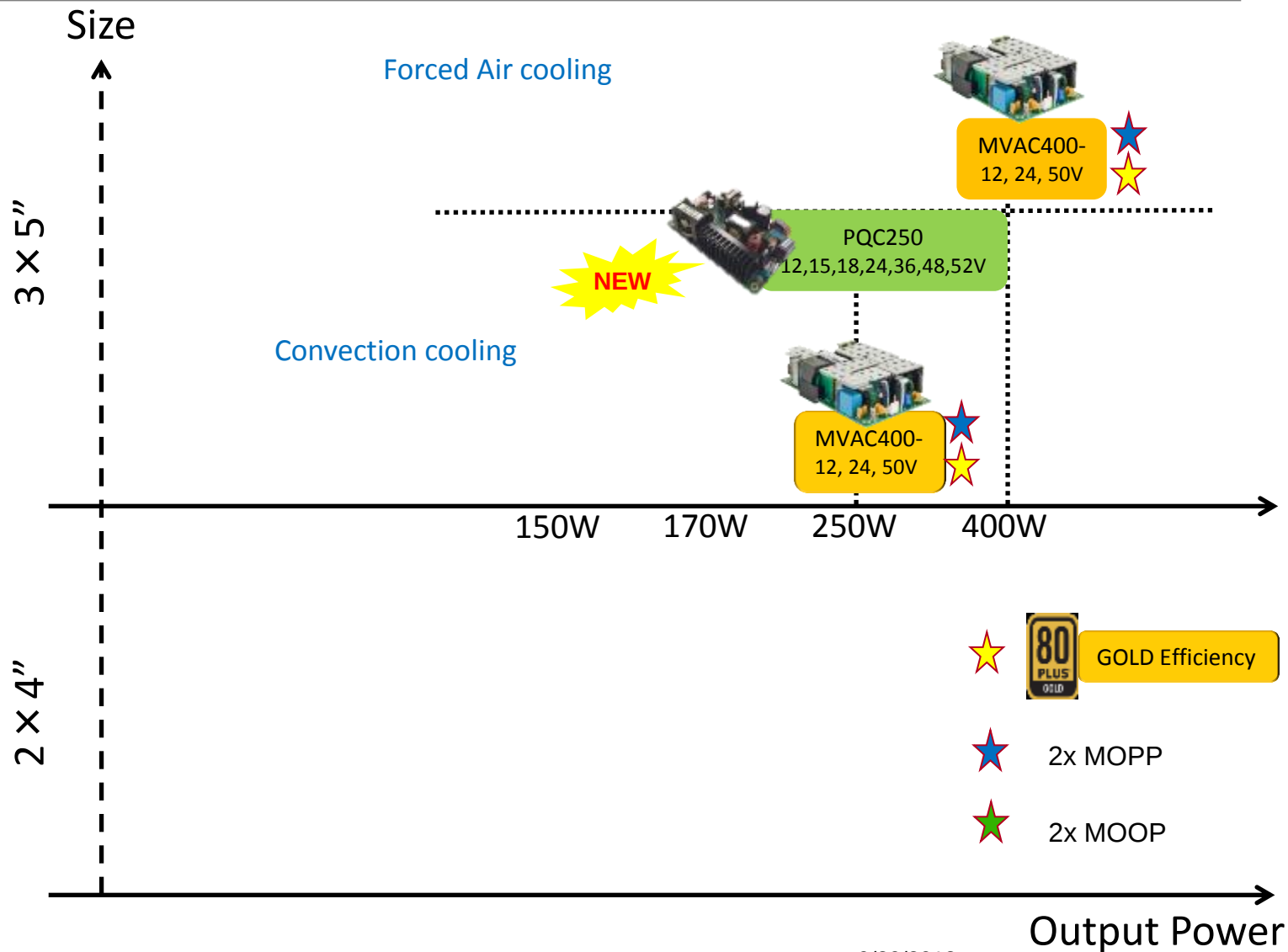


Estimated Launch Date: End 2018

AC/DC Open Frame & FEP



Open Frame AC/DC overview 2017

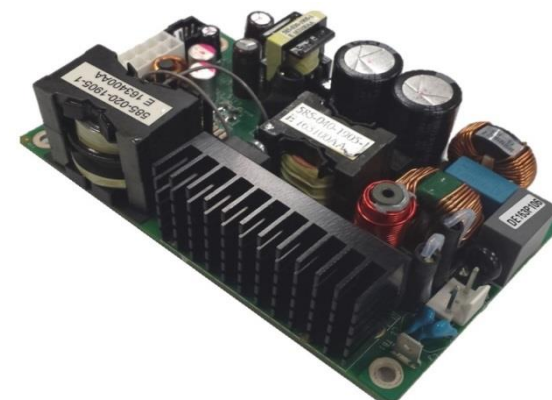


FEP PQC Series

Model Number	Convection Cooling	Forced Air	Input Voltage	Output Voltage	Standby Voltage	Efficiency	Dimensions
PQC250-12	250W	TBD	90-264Vac	12Vdc	5V @1A	93%	3" x 5" x 1.4"
PQC250-15	250W	TBD	90-264Vac	15Vdc		93%	3" x 5" x 1.4"
PQC250-18	250W	TBD	90-264Vac	18Vdc		93%	3" x 5" x 1.4"
PQC250-24	250W	TBD	90-264Vac	24Vdc		93%	3" x 5" x 1.4"
PQC250-28	250W	TBD	90-264Vac	28Vdc		93%	3" x 5" x 1.4"
PQC250-36	250W	TBD	90-264Vac	36Vdc		93%	3" x 5" x 1.4"
PQC250-48	250W	TBD	90-264Vac	48V		93%	3" x 5" x 1.4"
PQC250-54	250W	TBD	90-264Vac	54V		93%	3" x 5" x 1.4"

FEATURES

- ✓ IEC60601 Ed.3 medical (2 x MOPP Pri-Sec; 1 x MOPP Pri-Chassis Ground)
- ✓ IEC62368 (Combined IEC60950 & IEC60355)
- ✓ Designed to comply with IEC60601-1 4th Edition EMC Standard Requirements*
- ✓ 250W compact high density;
- ✓ Operation to 250W at +50°C
- ✓ Very low no load standby power; designed to meet ENERGY STAR® Program Requirements for Single Voltage External AC-DC and AC-AC Power Supplies
- ✓ True zero load operation of the Main "(V1) output;
- ✓ no minimum load requirements; correct PS_OK functionality maintained
- ✓ Remote sense



PQC250 is suitable for customers that have challenge with:



Limited /No Airflow

- Customer has challenge with limited airflow in their system
- Customer has a sealed /enclosed product with no fan
- Customer needs at least 200W power driven from a PSU in a sealed, fan less environment when temperature inside can get up to 70C.
- Customer prefers maintenance free/ dust tight product. Normally life expectancy is higher. therefore they prefer a sealed and fan less product. (Medical and Industrial Market)

Acoustic noise level

- Customer prefers convection cooled, fan less PSU. PQC250 series operates with full power (250W) up to 50C with no fan and derates to 200W at 70C.

Efficiency

- Customer requires highest efficiency. PQC250 achieved 95%.
- Customer requires lowest power dissipation at no load input. PQC dissipation is less than 0.5Watt.

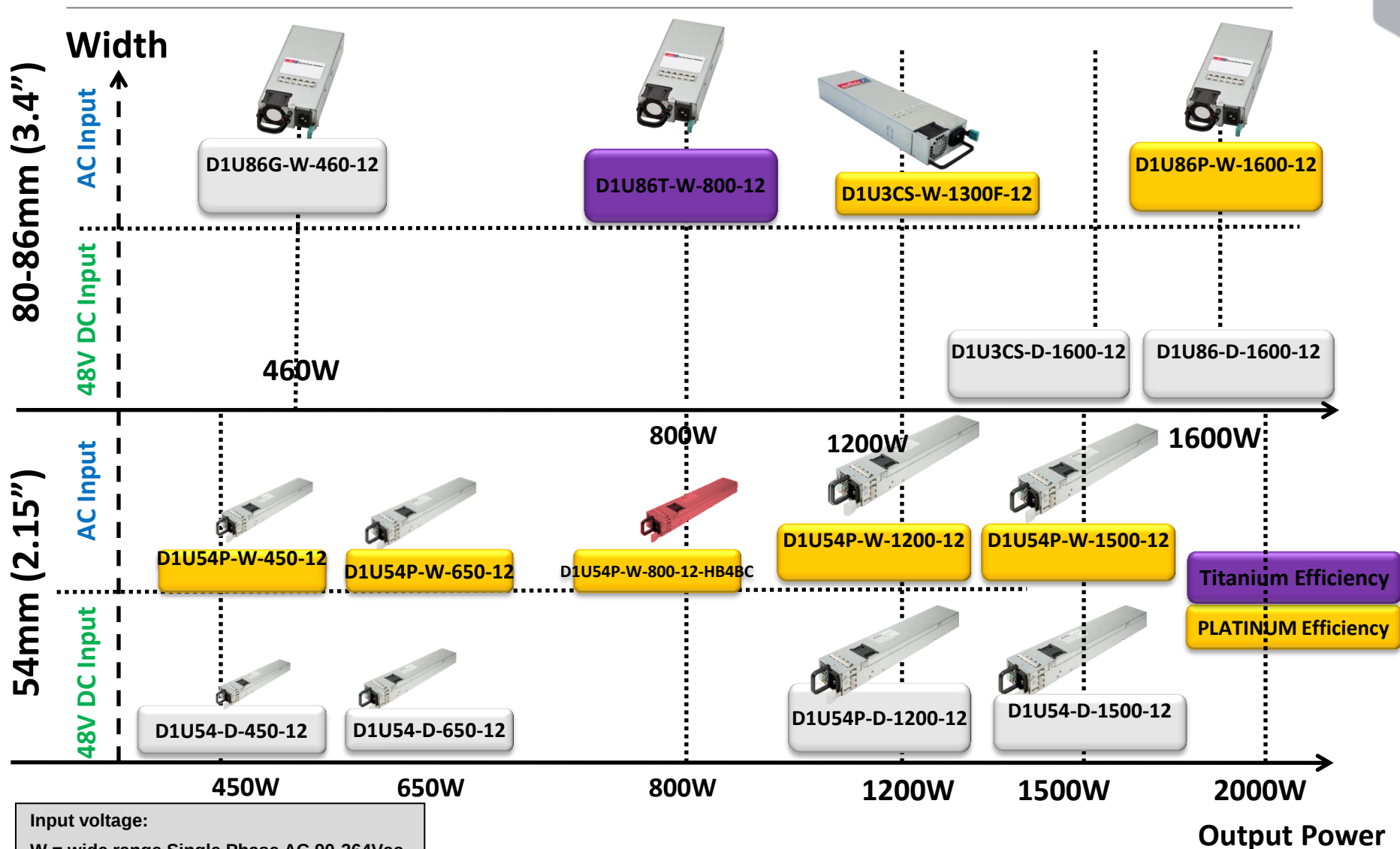
EMC

- Customer requires higher rate(class B) radiated and Conducted emission. PQC250 meets this level.

Application Examples

Market	Application
Industrial	Swimming Pool Salt Chlorinator, food quality control equipment, fire alarm panel, Wine tap system, ATM Kiosk, Betting Machines, Traffic control, Office, Flame/combustion controls, flame scanners,
Medical	Surgical light, PET/CT Scanner, Ultrasound monitors, blood pressure monitors, incubators, ECG equipment, and operating tables
Video	Video Conference system, Multiplexer
Consumer/Home Appliances	Coffee maker

54mm to 86mm Wide - Front End Product Landscape



Input voltage:

W = wide range Single Phase AC 90-264Vac

D = DC input, typically -40 to 72Vdc

D1U54 Series

High density in only 54mm form factor

NA /RA airflow
1200W,1300W,1500W:1U height: 2.15" x 12.65" x 1.57"
650Watt,750Watt:1U height: 2.19" x 9" x 1.57"

D1U54 Series

High Density

28 Watts per cubic inch density

Powerful

450, 650, 750, 1200 Watt , 1300 and 1500Watt

AC-DC:Input 90-264 Vac, 12 Vdc output, Standby 3.3 or 5 Vdc or 12Vdc

DC-DC:Input 40-72 Vdc, 12 Vdc output, Standby 3.3 or 5 Vdc or 12Vdc

Efficient

Best in class 80 PLUS Platinum Efficiency >94% @50%
Load, minimum power dissipation

Redundant

N+1 Redundant, hot pluggable, ORing FET, Parallel
operation with active digital current sharing

Intelligent

I²C communication interface for control, programming and
monitoring with PMBus™ protocol



High Density 460W to 1600W in 86mm

Interchangeable AC or DC input modules

D1U86 Series

Highest Density

Up to 45.8 W/in³ density

Powerful

460 Watt:

Input 90-264 Vac

12 Vdc output, 12Vdc Standby

800Watt:

Input 90-264 Vac

12 Vdc output, **TITANIUM** Efficiency

1600 Watt

Input 90-264 Vac or 40-72Vdc,

12 Vdc output, 12Vdc Standby

Efficient

Best in class 80 PLUS **Platinum** Efficiency >94%
@50% Load, minimum power dissipation

Redundant

N+1 Redundant, hot pluggable, ORing FET,
Active current sharing

Intelligent

PMBus interface with status indicators

Production
March 2017

NA /RA airflow
3.4" x 7.75" x 1.57"
86.4 x 198 x 40.5mm



D1U86P-W-1600-12-HxxDC shown



DC input



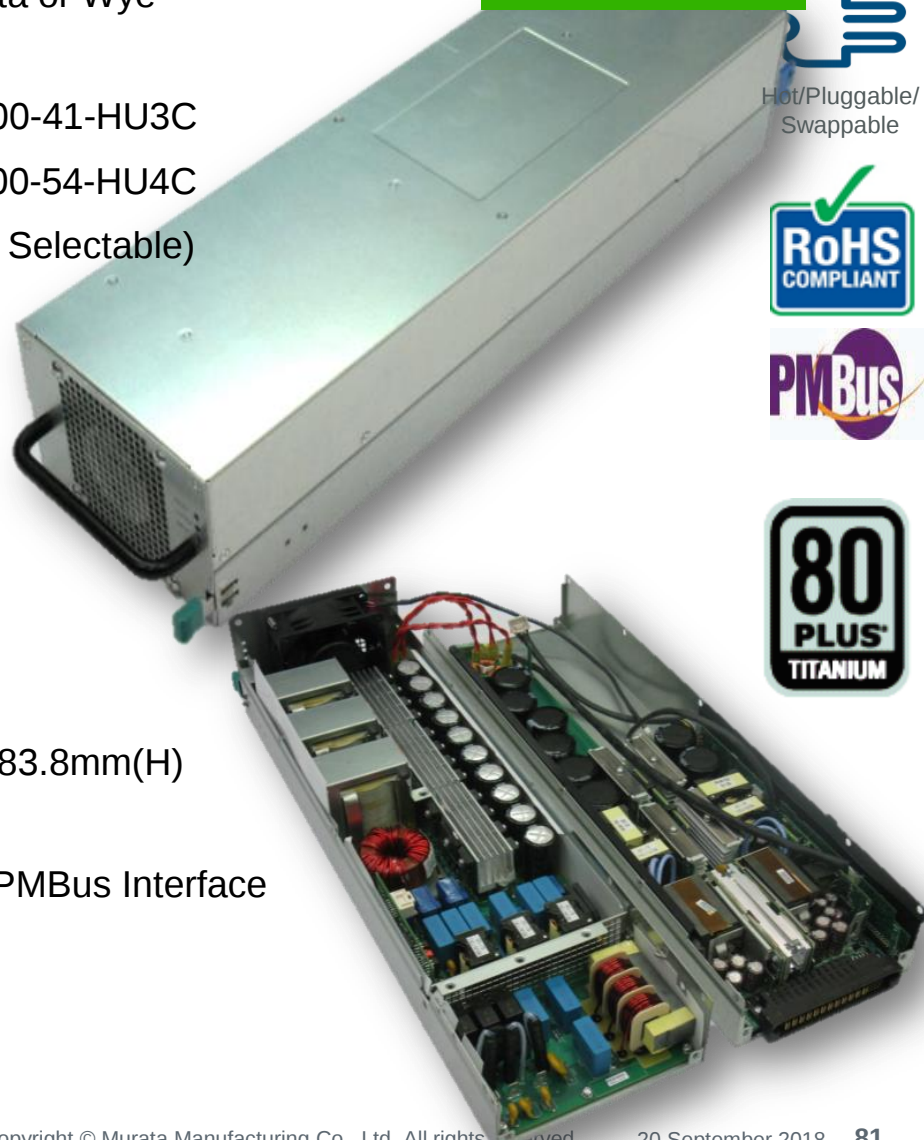
Hot/Pluggable/
Swappable



D2U5T Series – 7000W

- **Input** 320 to 528Vac, 3-Phase Delta or Wye
180 to 305Vac at 3500W
- **Output** 41Vdc/170A; D2U5T-H3-7000-41-HU3C
54Vdc/130A; D2U5T-H3-7000-54-HU4C
- **Standby** 3.3Vdc/6A or 5Vdc/4A (User Selectable)
- **Power** 7000W Max
- **Efficiency** Titanium
- **Ride through** 12mS
- **Cooling** Forced Air, Internal Fan
- **Redundant** N+1, OR-ing FETs
- **Operating temp** 0° to 50°C
- **Topology** Vienna Rectifier
- **Mechanical** 457mm(L) x 129.5mm(W) x 83.8mm(H)
(18.00"x5.1"x 3.3")
- **Others** Input & Output Reporting & PMBus Interface

In Production



3Phase AC-DC Converter 5Kwatt

- **Input** 320 to 528Vac, 3-Phase Delta or Wye
180 to 305Vac at 3500W
- **Output** +380Vdc/13.2A;
- **Standby** 3.3Vdc/6A or 5Vdc/4A (User Selectable)
- **Power** 5000W max
- **Efficiency** Platinum Plus
- **Ride through** 25mS
- **Cooling** Forced air, internal fan (towards connectors)
- **Redundant** N+1 or N+N redundant
- **Operating temp** -15° to 50°C
- **Topology** Vienna Rectifier
- **Mechanical** 457mm(L) x 129.5mm(W) x 83.8mm(H)
(18.00"x5.1"x 3.3")
- **Others** Input & output reporting & I2C interface

In Production



Hot/Pluggable/
Swappable



Focus Industrial Panel Meter Products

- ✓ Industrial customers will also have interest in the Digital Meter products



Panel Instrumentation for Industrial Markets

Murata Power Solutions offers a full line of digital panel meters that can accurately measure...

- ✓ **AC Volts:** up to 600V
- ✓ **AC Amps:** up to 2000A
- ✓ **AC Watts:** up to 26.4kW
- ✓ **AC Frequency:** 45 to 450Hz
- ✓ **DC Volts:** up to 430V
- ✓ **DC Amps:** up to 1200A
- ✓ **Temperature:** -40 to +100°C (-40 to +212°F)
- ✓ **Process Control:** 4-20mA Current Loop



A full line of accessories and tooling is available, including shunts and CTs



DC shunts



Current transformers





Thank you!

