



The Power to Amaze.

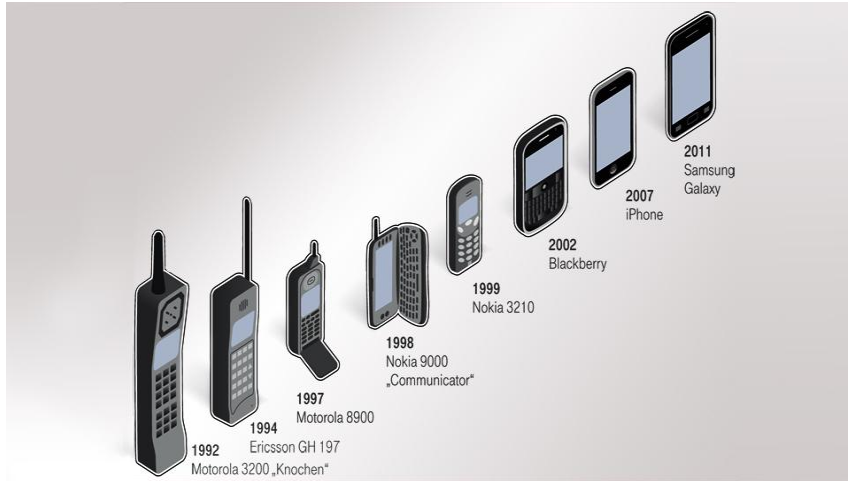
A collage background image featuring a group of men in business suits on the left, a wind turbine in the center, and the front of a car on the right.

Compact Power Modules for Motion Control

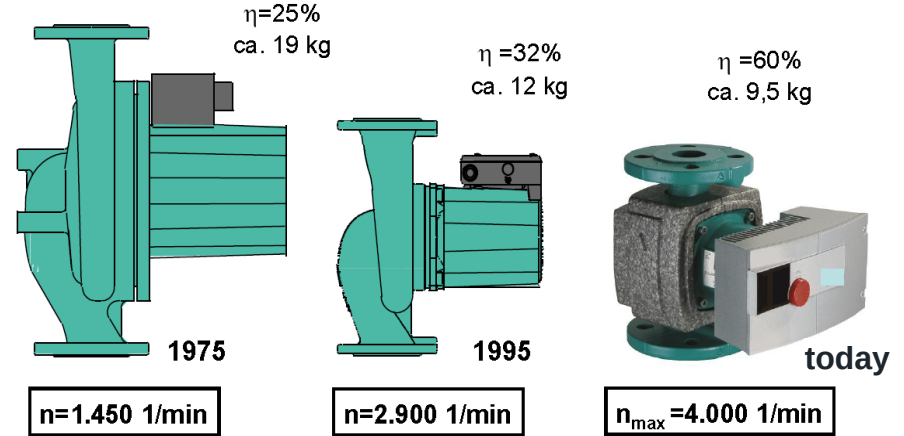
Hyunsoo Song / FAE

September 3, 2014

Technical evolution

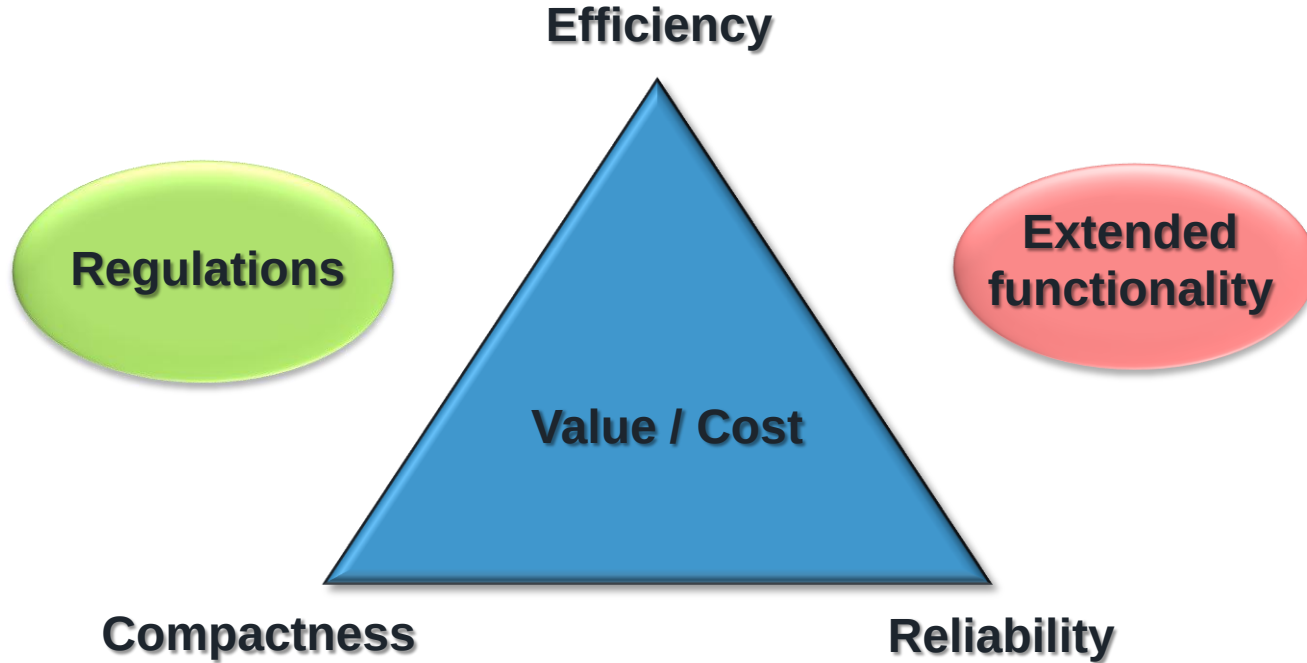


Evolution in Motion control



Example of a Circulation-Pump (Source: WILO SE)

Market Trend in Motion Control





Market Drivers

- Energy Regulations
 - Each country has been strengthening 'Energy Efficiency Level' for saving energy
 - Recently, this kind of inverterization trend is spreading to below 100 W wattage solution, not only big power solution.
- Customers Demand
 - Requiring higher efficiency
 - Need solutions that help reduce PCB space
 - Want lower price Bill of Materials (BOM) costs

Low Power Motion Control Applications

Pumps:

- Dishwasher
- Washing machine
- Circulation-pump
- Small pumps



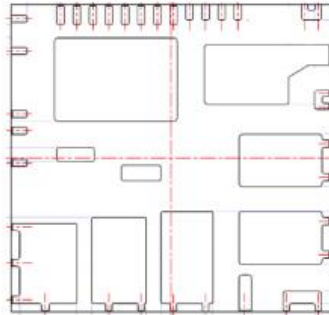
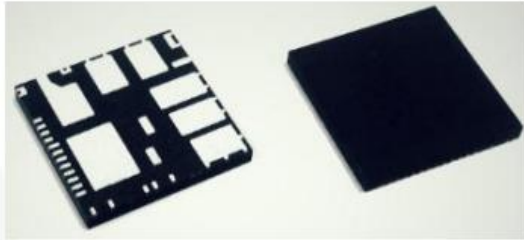
Fans:

- Kitchen hood
- Ventilation unit
- Air-Conditioner(Indoor/Outdoor)
- Pedestal/Ceiling fans





Compactness Module (SPM[®] 7 Series) for Low Power Motion Control



BOTTOM VIEW



FRONT VIEW



Package
12.9 x 12.9 x 1.3 [mm]
Power-QFN

Reduce PCB space up to 50%,
BOM cost up to 33%

Higher efficiency

Leading thermal,
EMI performance

**NEW
INVERTER MODULE**
DRIVES DOWN
SIZE & COST

Motion SPM[®] 7 FSB70xxx Series

- 6-in-1 HVIC with full protection function
+ six FRFET[®] MOSFETs integrated in a single package
- Ideal for small motors under 100 W

FAIRCHILD



Advantages of SPM® 7 Series

- **Optimized FRFET® MOSFET**

- New SPM® series adopted UniFET™ II FRFET® MOSFET version for 250 V / 500 V
- Will add 600 V SuperFET® II MOSFET version

- **Lower Thermal resistance**

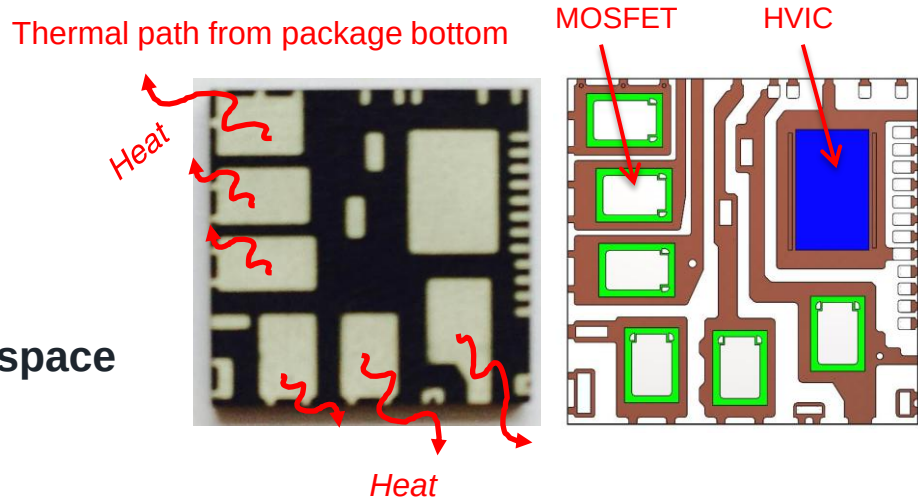
- * FSB70450 : (0.8) degree/watt

- **Compact package size for minimizing PCB space**

- Up to 50% reduction in PCB space

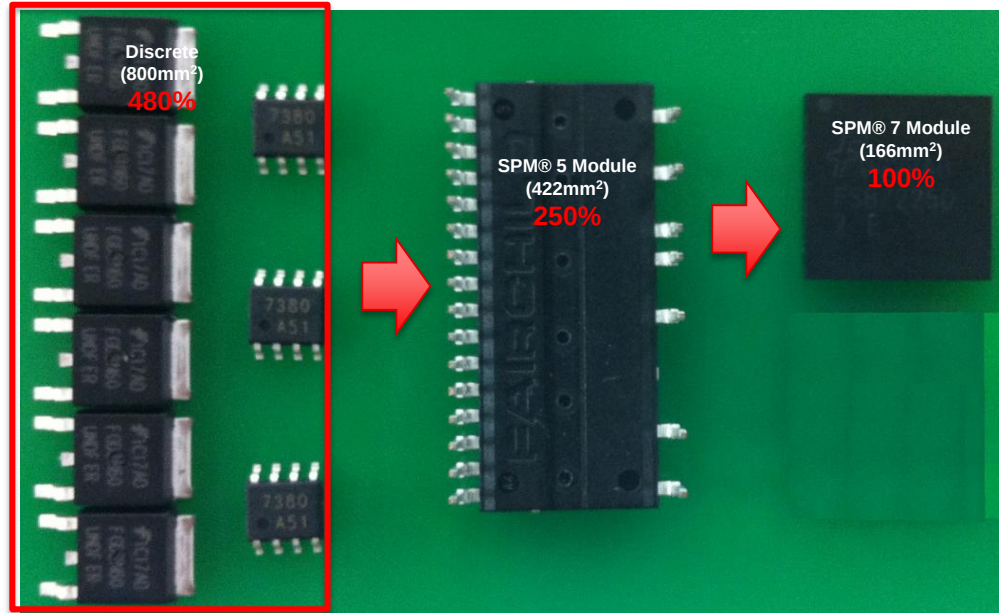
- **Optimized EMI performance**

- Stable di/dt , dv/dt





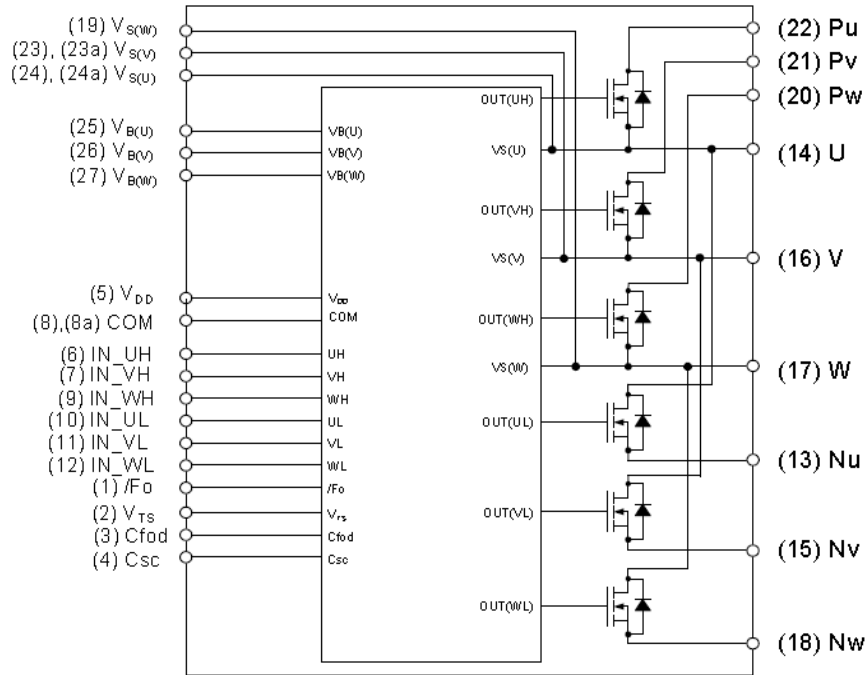
Package Size Comparison: Discrete vs. SPM® 5 Series vs. SPM® 7 Series





Motion Control < 100W

SPM® 7 Module What's Inside?



Features:

- Robust & High Efficient UniFET™ MOSFET
→ SC withstand time is over 10us @ Worst Case
- Low EMI
→ Reduced dv/dt
- Thermal Sensing for temperature monitoring
→ Analog voltage output (can be sensed by MCU)
- Full Protection:
 - High/Low side Under Voltage Lockout
 - Overcurrent protection
 - Interlock function
 - "Fault out" for abnormal condition

Product Line up : FSB70625 - 250V/ 0.8Ωmax.

FSB70325 - 250V/ 1.4Ωmax.

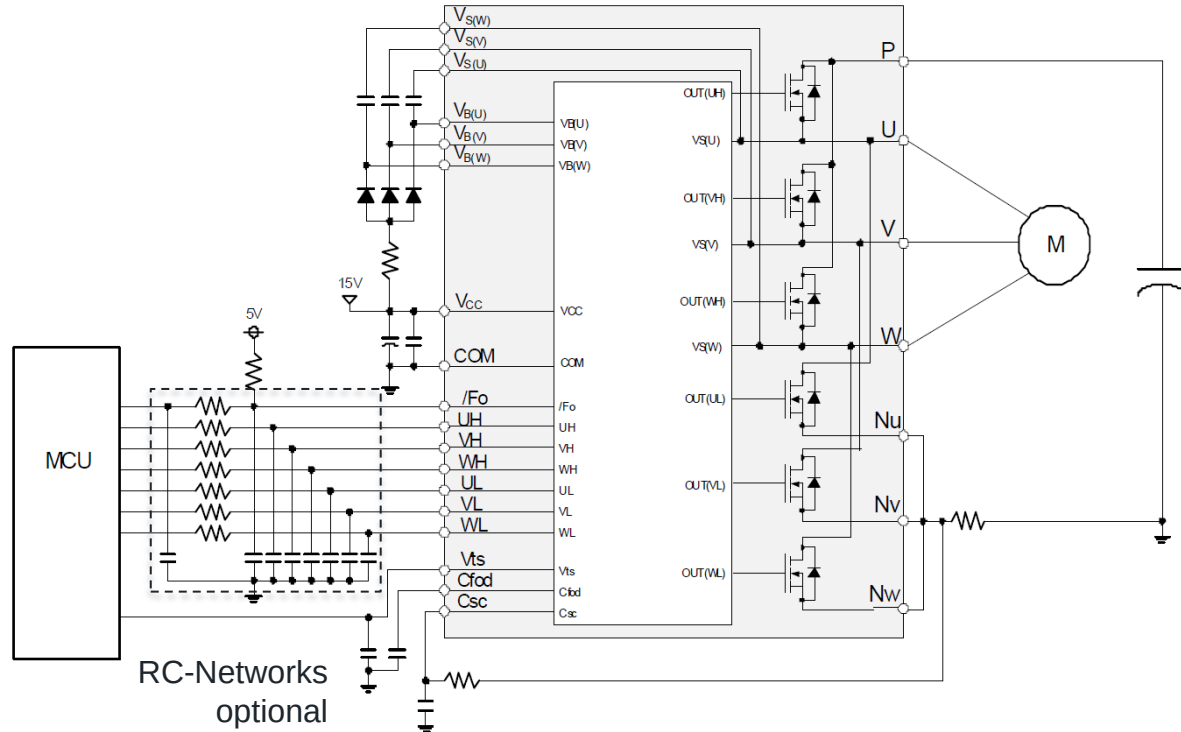
FSB70550 - 500V/ 1.85Ωmax.

FSB70450 - 500V/ 2.2Ωmax.

FSB70250 - 500V/ 3.4Ωmax.

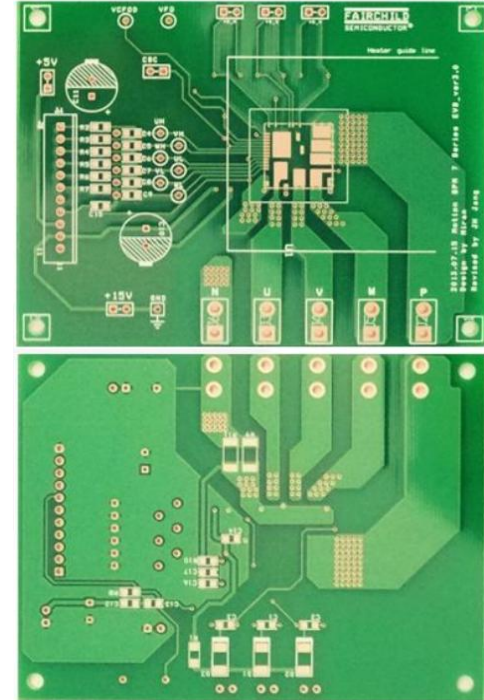
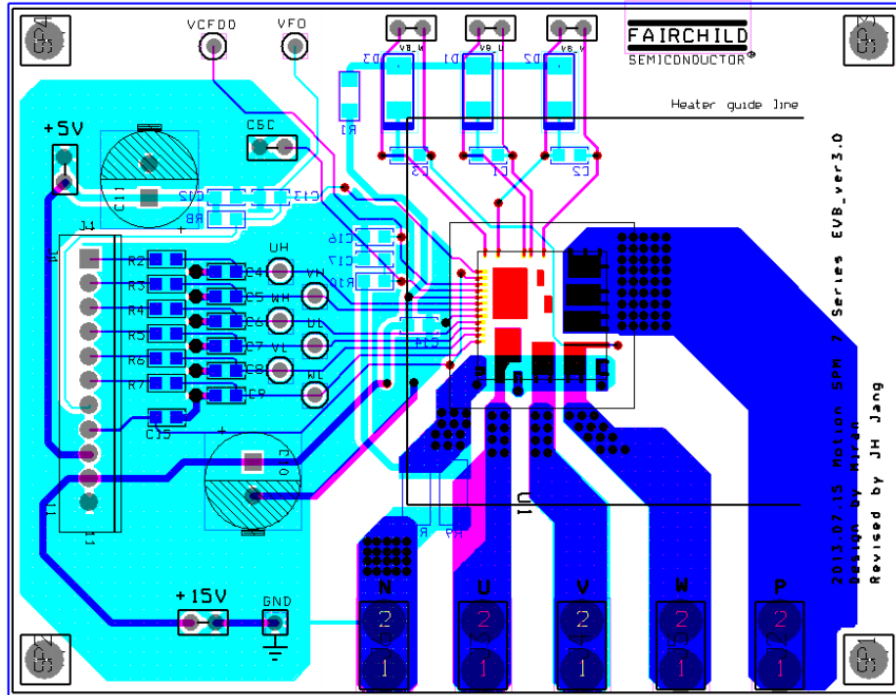
Motion Control < 100W

Application Schematic SPM® 7 Module

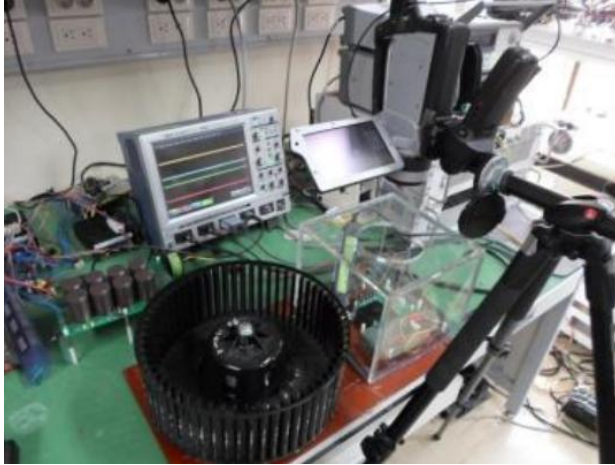




PCB Layout Example for SPM® 7 Series



Thermal Characteristics by Cu Thickness of PCB



Test Condition

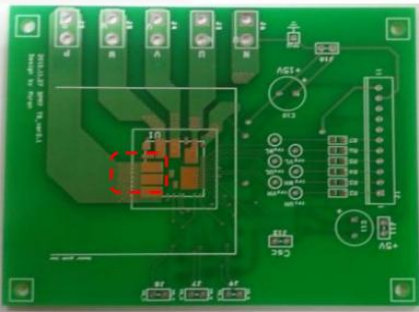
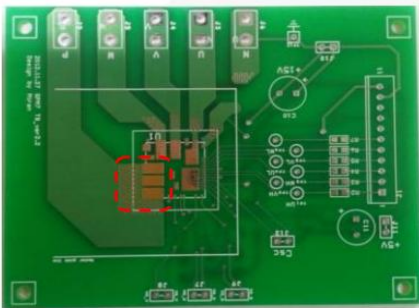
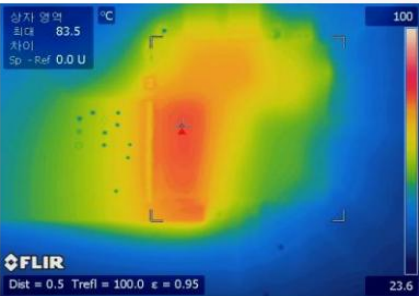
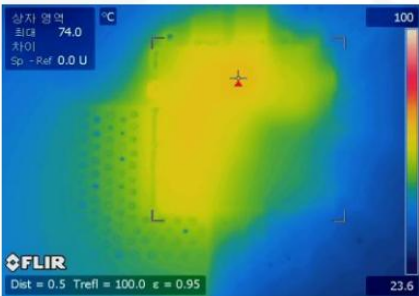
- $V_{DC} = 300\text{ V}$, $V_{DD} = V_{BS} = 15\text{ V}$, $f_{SW} = 16.6\text{ kHz}$
- PWM method: SVPWM
- Output current = 0.3/0.4/0.5 Arms
- No heat sink
- Test board: FR4, 2 layer, 1 oz & 2 oz.

Effect of Cu Thickness

Copper Thickness	0.3 Arms	0.4 Arms	0.5 Arms
1 oz	69.2°C	91.5°C	
2 oz	58.8°C	75.3°C	100°C

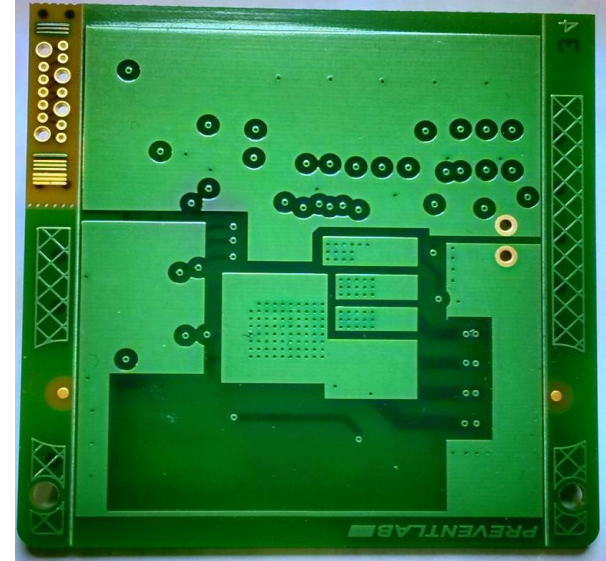
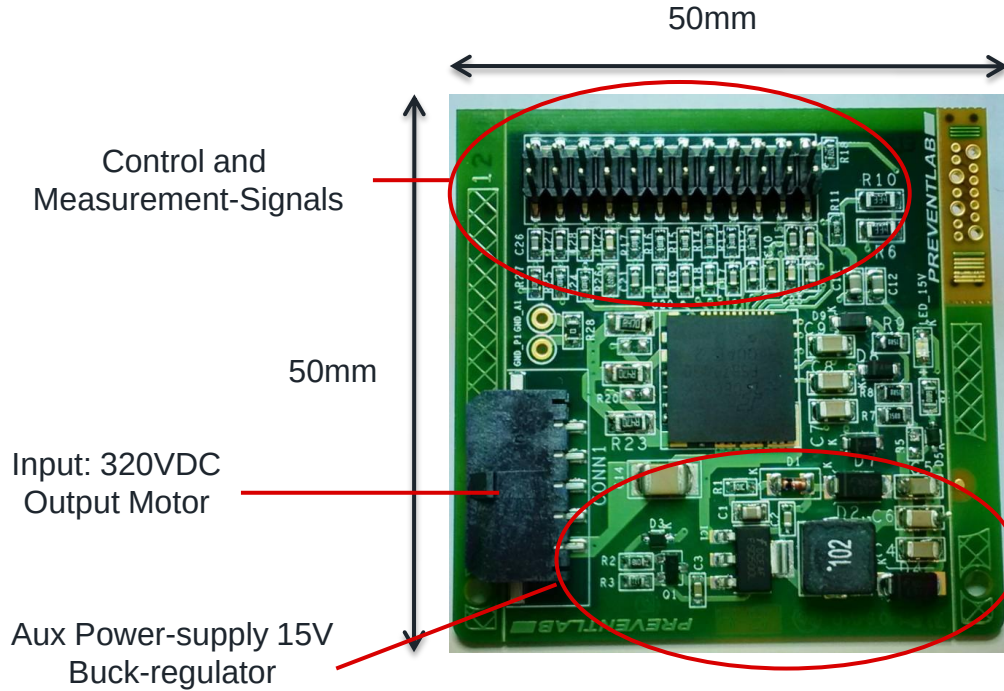
Thermal Characteristics by PCB Pattern Width

Effect of Pattern width at $I_{rms} = 400\text{ mA}$, 1 oz, $T_A = 21^\circ\text{C}$

Narrow Width (10 mm)	Wide Width (20 mm)
83.5°C	74°C
	
	

- $V_{DC} = 300\text{ V}$, $V_{DD} = V_{BS} = 15\text{ V}$, $f_{sw} = 16.6\text{ kHz}$
- PWM method: SVPWM
- Output current = 0.4 Arms
- No heat sink
- Test board: FR4, 2 layer, 1 oz

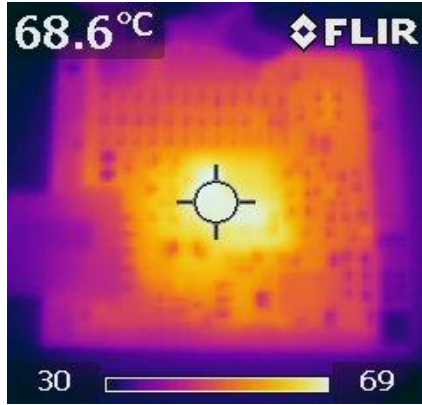
Test Results with FSB70450 Demo-Board



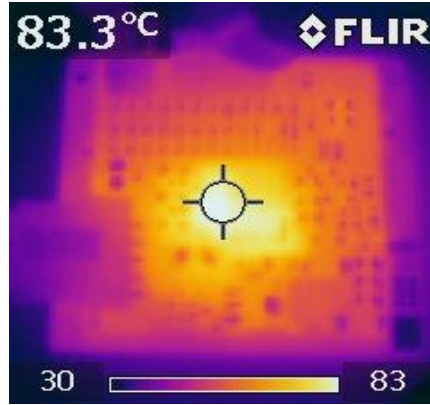
PCB: Standard 4 Layer 35um Cu



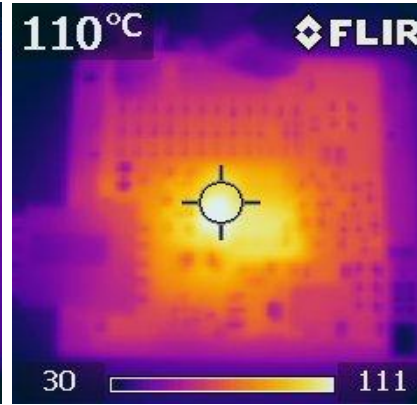
Demo-board with FSB70450 (No heatsink, $T_a=20^\circ\text{C}$)



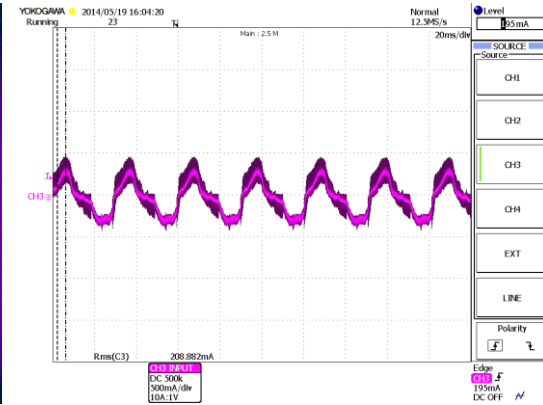
$V_{in}=320\text{VDC}$
 $I_{\text{motor}} = 200\text{mA}$
 $P_{out} \approx 60\text{W}$
 $F_{sw}=15\text{kHz}$
 $T_{max}=68,6^\circ\text{C}$



$V_{in}=320\text{VDC}$
 $I_{\text{motor}} = 300\text{mA}$
 $P_{out} \approx 90\text{W}$
 $F_{sw}=15\text{kHz}$
 $T_{max}=83,3^\circ\text{C}$



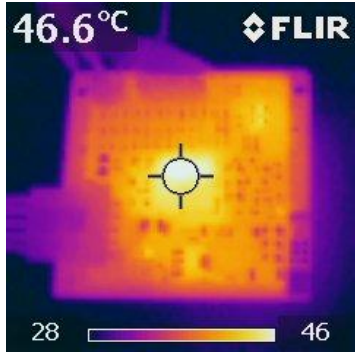
$V_{in}=320\text{VDC}$
 $I_{\text{motor}} = 400\text{mA}$
 $P_{out} \approx 120\text{W}$
 $F_{sw}=15\text{kHz}$
 $T_{max}=110^\circ\text{C}$



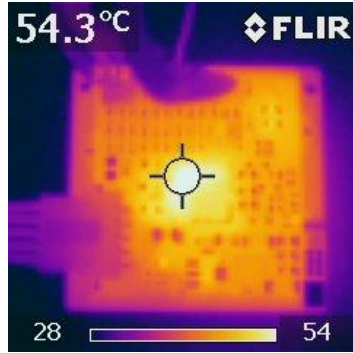
Current waveform



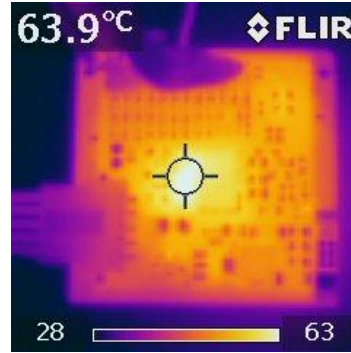
Demo-board with FSB70450 (With heatsink, $T_a=20^\circ\text{C}$)



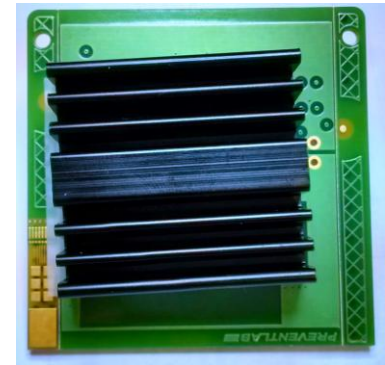
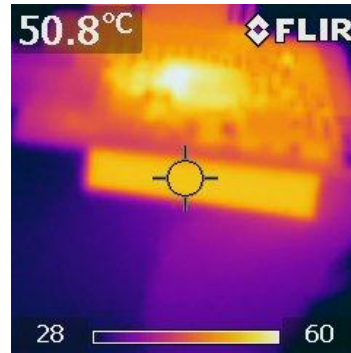
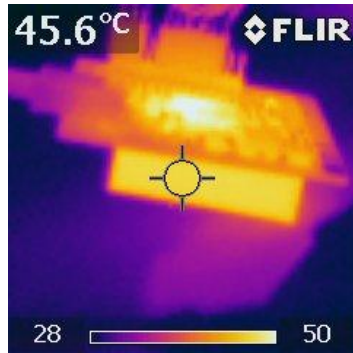
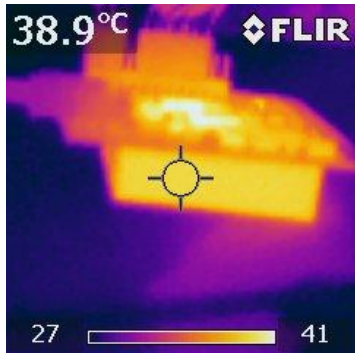
200mA (60W)



300mA (90W)

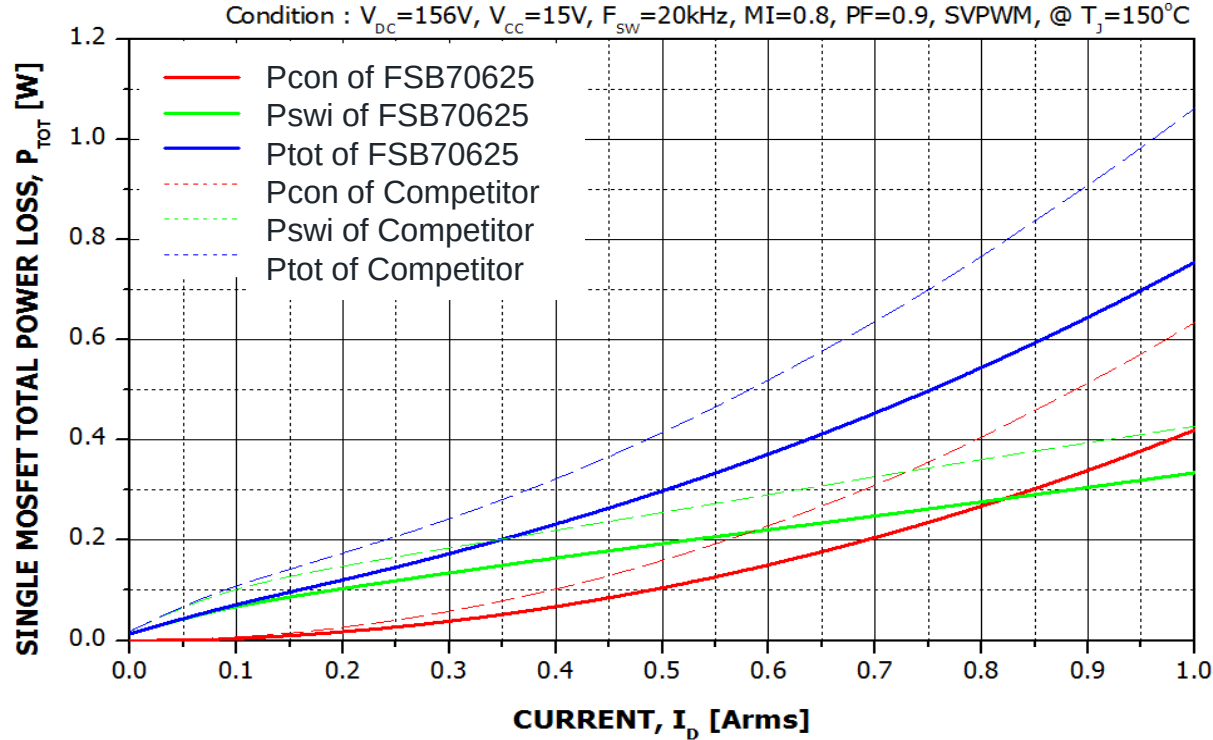


400mA (120W)

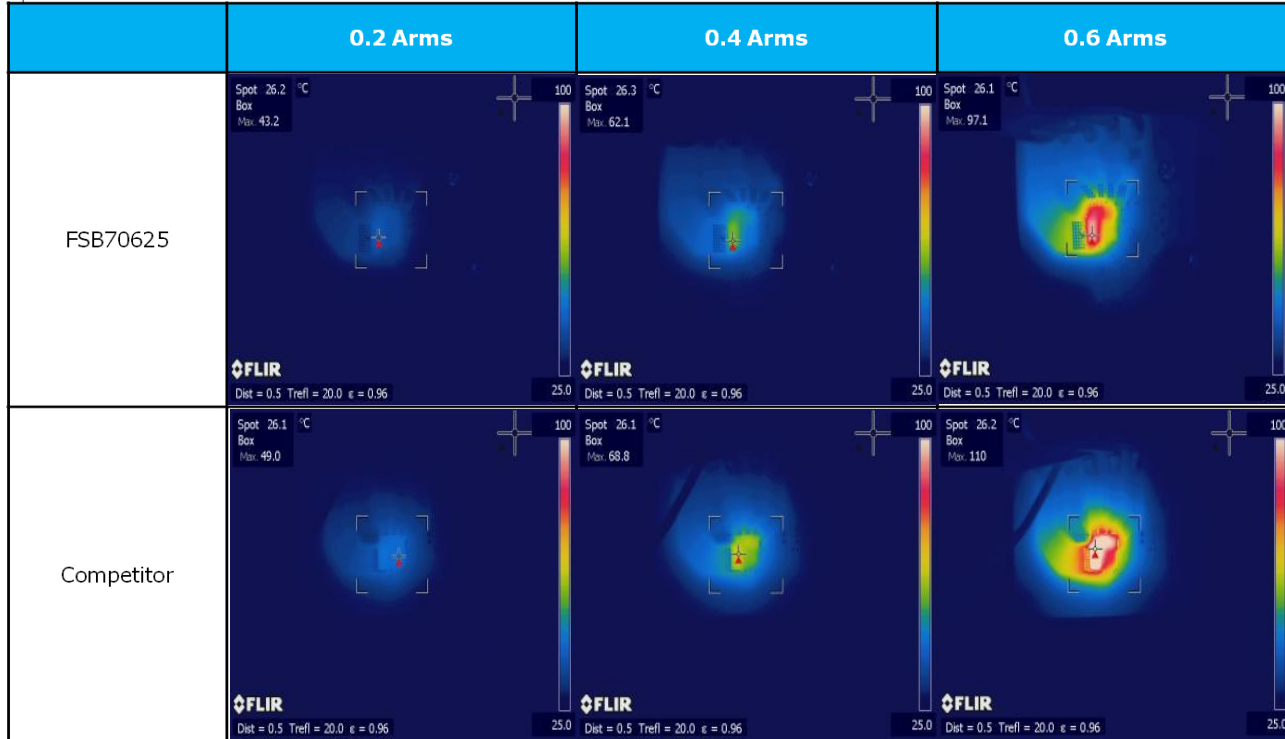




Total Loss Simulation Result



Module Temperature Performance

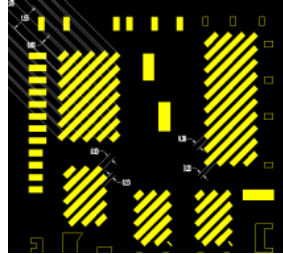


Test condition ; Vdc=156 V, Vcc=15 V, Fsw=20 KHz, Control Method = Sine-wave current control

What about manufacturability ?

Recommendations to:

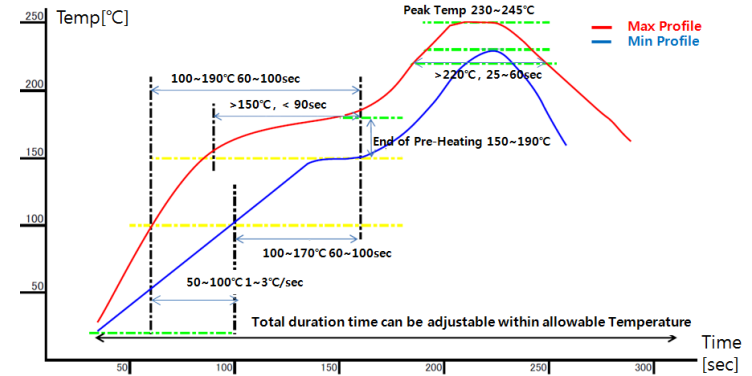
- Solder-paste type
- Stencil-Design
- Solder-profile
- X-ray-Inspection

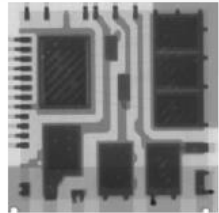
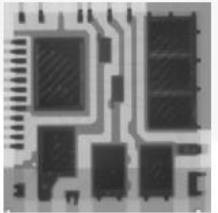


X-ray-Analysis of different options

Application Note Available on the web

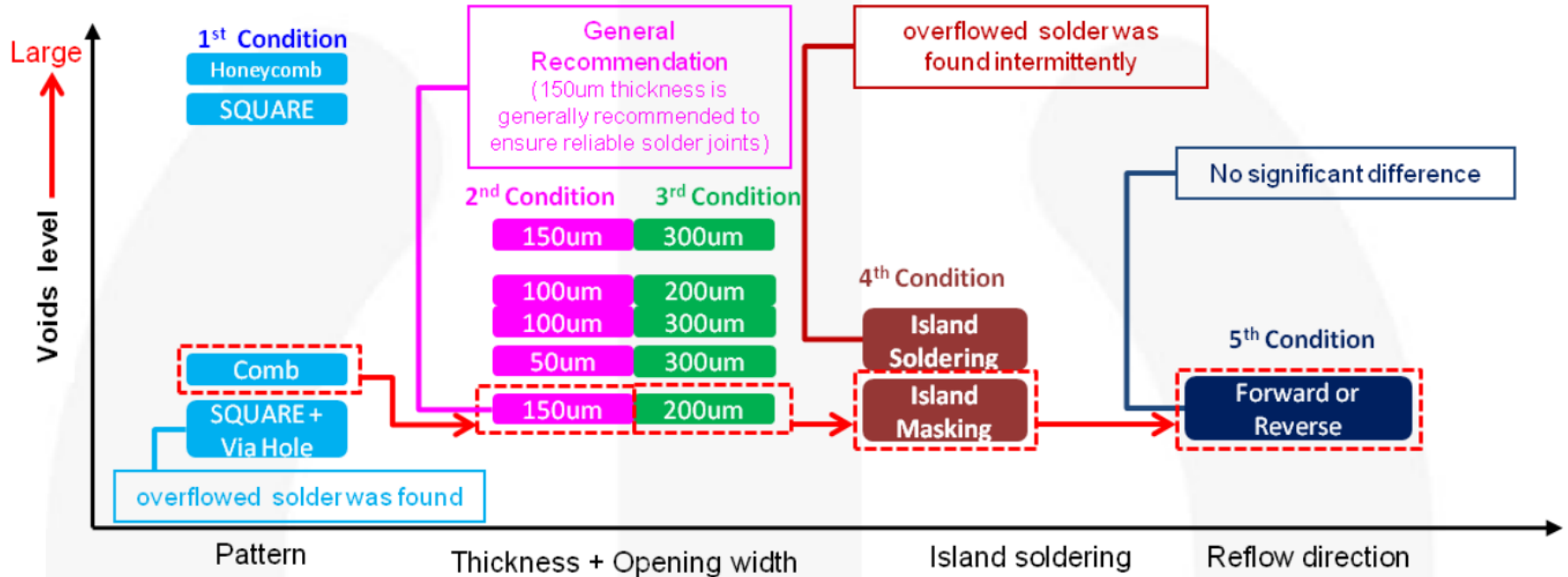
AN-9078 Surface Mount Guidelines for Motion SPM® 7 Series



Condition	X-Ray	
100 μm Thickness, 200 μm Opening Width		
	Void Level ≈ 19%	Void Level ≈ 20%

Recommended conditions

AN-9078 Surface Mount Guidelines for Motion SPM® 7 Series





Why Choose Our SPM® Modules

- The widest breadth of packaging for motor control applications (below 10 HP)
- Optimized packaging for thermal performance, high-power density, and robust assembly
- Compactness for low/mid-power industrial applications
- Wide range of guaranteed junction temperature: -40 °C to +150 °C
- Packages with more creepage/clearance distance
- Better ruggedness, optimized conduction losses and switching losses

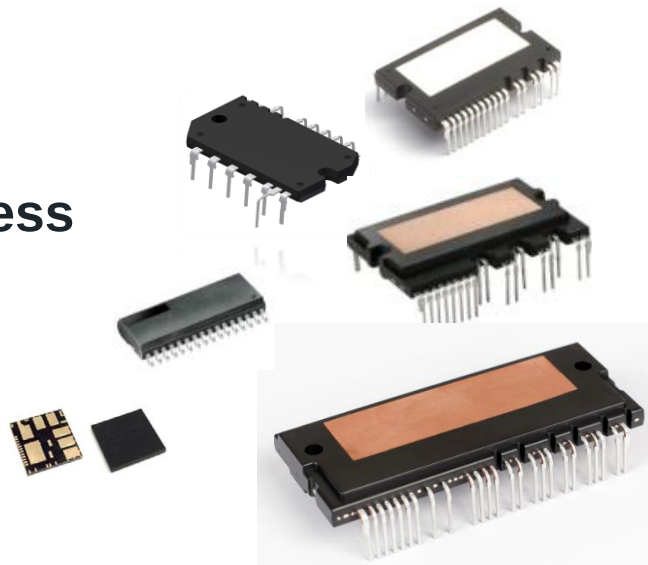


Highly Integrated Solution from Fairchild:

SPM® Smart Power Modules up to 10kW

Provide:

- Efficiency
- Compactness
- Reliability

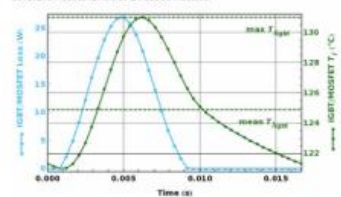


See examples below of tabular and graphical evaluation results:

FBS3CH80 3A 600V		
Parameter	Value/Units	
DC Input Bus	340	Volts
RMS Motor Phase Current	5	Amps
Motor Power Factor	95	Percent
Modulation Depth	90	Percent
Ambient Temperature	60	Celsius
Switching Frequency	8	kHz
Output Modulation Frequency	60	Hz

Parameter	Value	Units
Drive Output Power	2.07	Horsepower
Drive Output Power	1542	Watts
Output Vac line-2-line	187.4	Volts
Loss Per IGBT or MOSFET	7.3	Watts
Loss Per Diode	0.7	Watts
Total Module Loss	47.9	Watts
Max Case Temperature	95.2	Celsius
Max HS Temperature	92.3	Celsius
Max case Temp Limited by Tj max	-	-
Max Heatsink Rthca	0.67	CW
Heatsink Rth Determined	Using Calculated Rsin	-
Average IGBT Tj	125	Celsius
Peak IGBT Tj	131	Celsius
Minimum IGBT Tj	131	Celsius
Average FWD Tj	-	-
Case Temp Tj	-	-

Graph 1 - IGBT or MOSFET losses and junction temperature versus time for full load conditions specified below. MOSFET losses include body diode conduction losses for MOSFET based modules.



Graph 2 - Copacked diode losses and junction temperature versus time for full load conditions specified below. Graph will straight line for MOSFET based modules since diode conduction losses are included in MOSFET.



Calculation-Tool

* Motion Control Design Tool *

<http://www.fairchildsemi.com/support/design-tools/motion-control-design-tool/>



Related Documents & Tool

- Datasheet

[FSB70625](#) - 250V/ 0.8 Ω max.

[FSB70325](#) - 250V/ 1.4 Ω max.

[FSB70550](#) - 500V/ 1.85 Ω max.

[FSB70450](#) - 500V/ 2.2 Ω max.

[FSB70250](#) - 500V/ 3.4 Ω max.

- Application notes & Reference Design

[AN-9077](#) Motion SPM® 7 Series User's Guide

[AN-9078](#) Surface Mount Guidelines for Motion SPM® 7 Series

[RD-356](#) Reference Design RD-356

- Design Tool

[Motion Control Design Tool](#)



THANK YOU