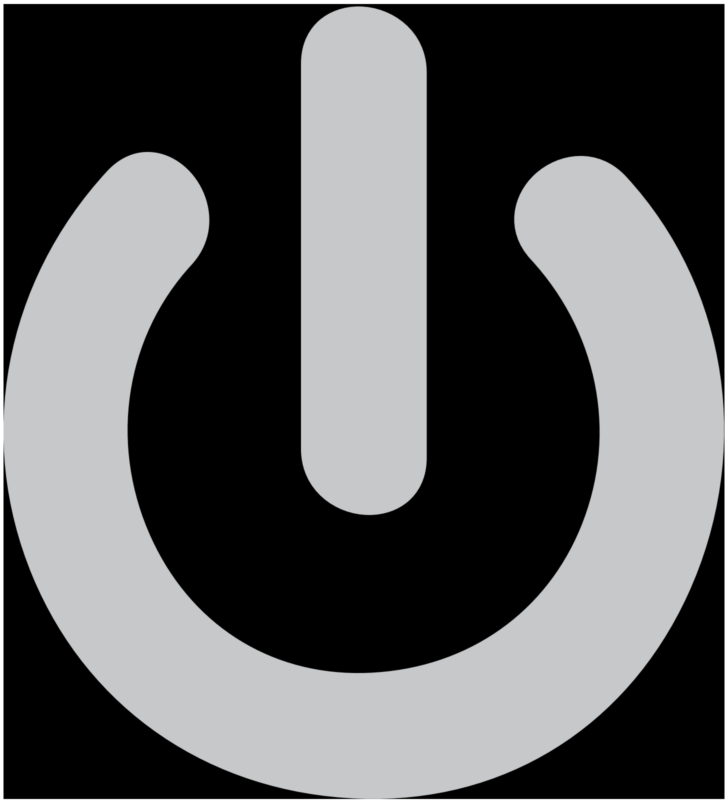
FEB155-001 User's Guide
Motor Control Evaluation Board Using the Motion-SPM™ (FSB50450) in a Tiny-DIP (29mm x 12mm) Package



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1. Introduction

This user's guide supports the FSB50450, Motion-SPM™ in a Tiny-DIP package evaluation board. It should be used in conjunction with the FSB50450 data sheet.

1.1 Product Description

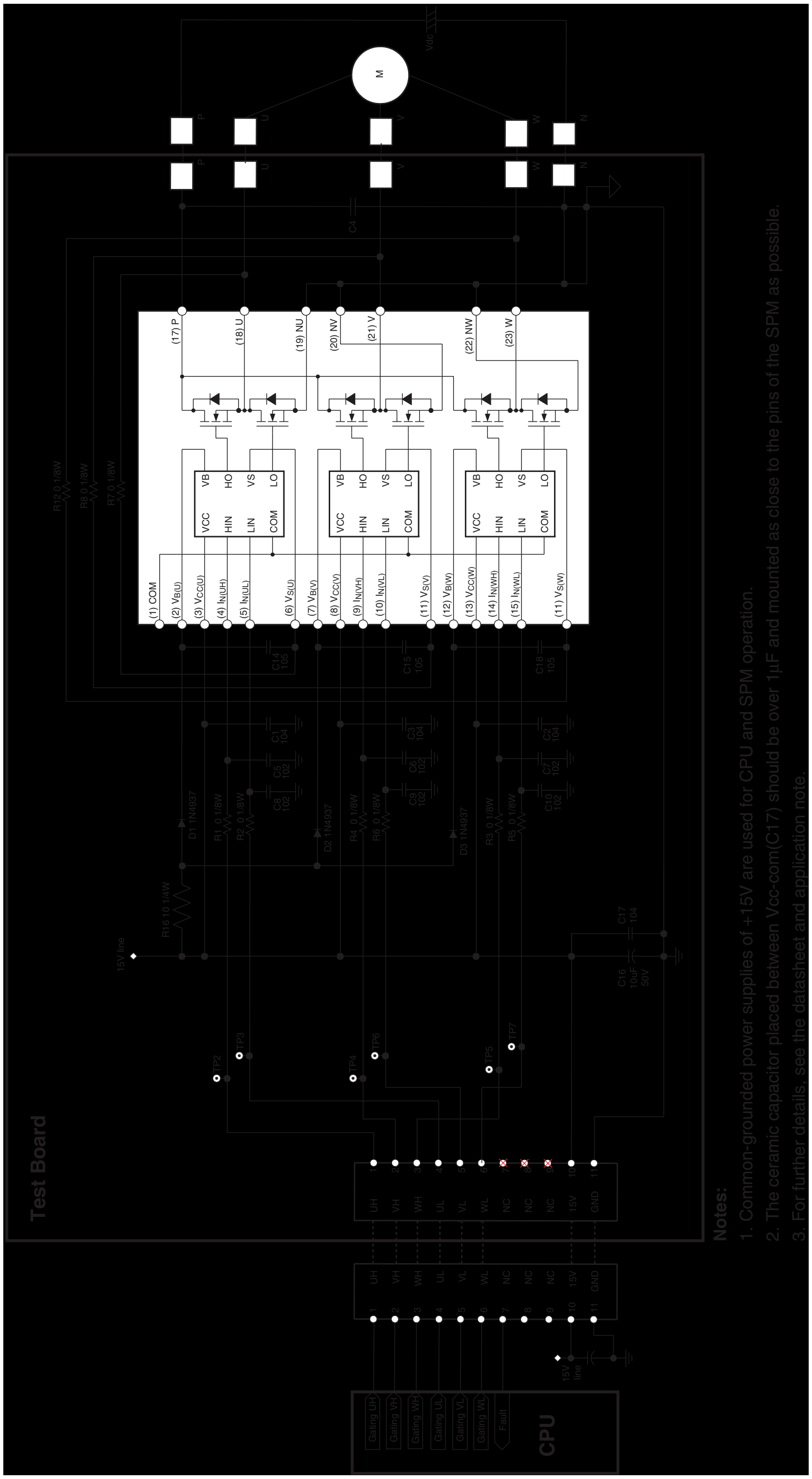
The Motion-SPM in Tiny-DIP combines six FRFETs and three half-bridge HVICs in a compact, thermally efficient, 29 x 12 mm DIP package. The FRFETs, featuring fast and soft recovery body diodes, offer a combination of lower switching losses, lower conduction losses at low current, and a wider reverse bias safe operating area (RBSOA) when compared to IGBTs. The body diodes are used as freewheeling diodes, eliminating the need for additional components. The Motion-SPM series is designed to enhance energy efficiency, lower electromagnetic interference, increase reliability and save PCB board space in low power brushless dc (BLDC) motor applications.

1.2 Circuit Description

The Motion-SPM is installed as the switching module in this evaluation board and has direct interface with the CPU. The DC-link(P and N) input terminals are connected into the corresponding terminals in Motion-SPM and three-phase (U,V,W) output terminals from SPM are wired into motor input. Since the three HVICs are integrated in the Motion-SPM, three parts of bootstrap circuit are needed, which consists of bootstrap capacitor, charge resistor for charging boost capacitor, blocking diode for high voltage isolation. Six R-C low pass filters are used between input connector from DSP (or other controller) and gate input signal pins of Motion-SPM

2. Designed Solution

2.1 Schematic



Notes:

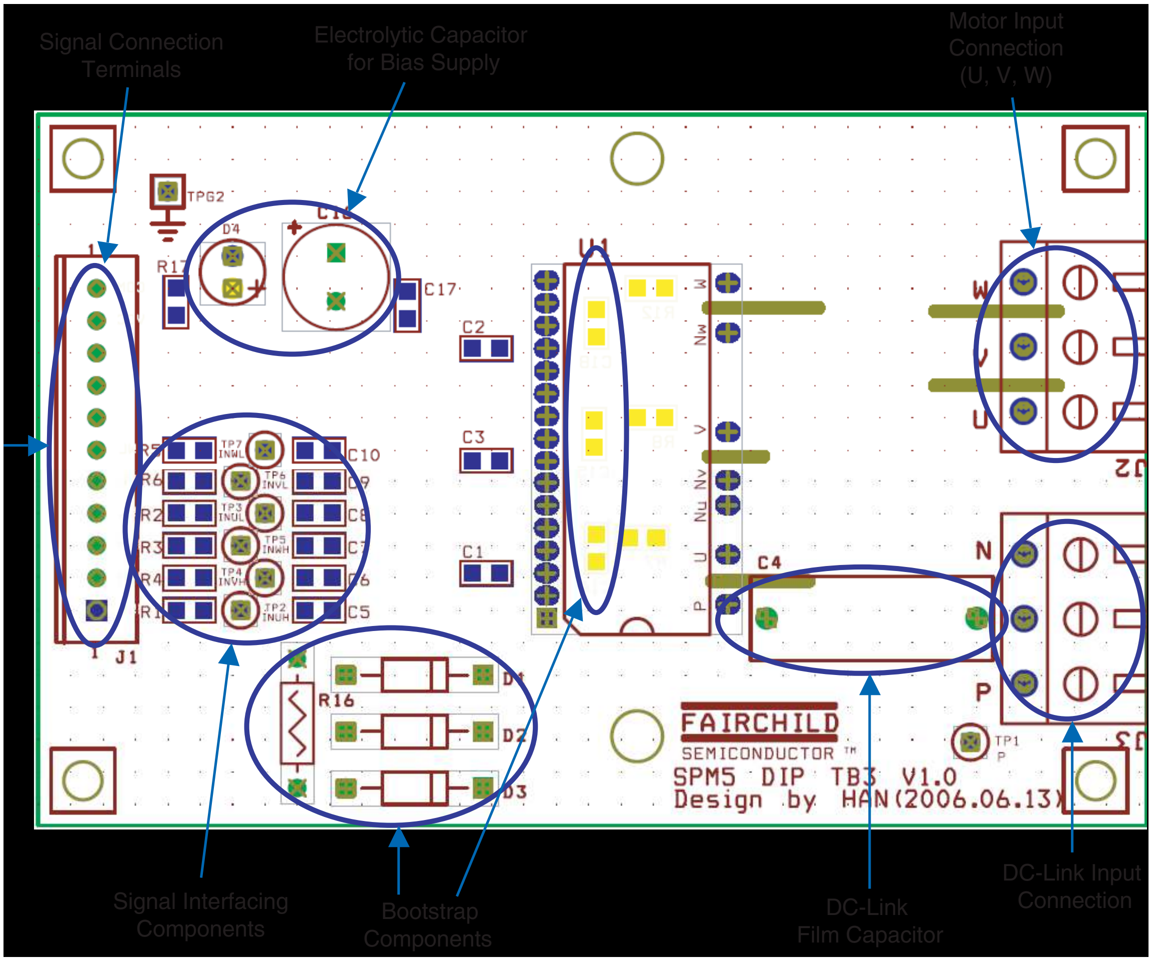
1. Common-grounded power supplies of +15V are used for CPU and SPM operation.
2. The ceramic capacitor placed between Vcc-com(C17) should be over 1μF and mounted as close to the pins of the SPM as possible.
3. For further details, see the datasheet and application note.

2.2 Bill of Materials

Part No.	Rating	Characteristics	Definition
R1	0Ω, 1/8W (2012)	Thick Film Resistor (5%)	Series Resistor for Signal Interface (UH)
R2	0Ω, 1/8W (2012)	Thick Film Resistor (5%)	Series Resistor for Signal Interface (UL)
R3	0Ω, 1/8W (2012)	Thick Film Resistor (5%)	Series Resistor for Signal Interface (WH)
R4	0Ω, 1/8W (2012)	Thick Film Resistor (5%)	Series Resistor for Signal Interface (VH)
R5	0Ω, 1/8W (2012)	Thick Film Resistor (5%)	Series Resistor for Signal Interface (WL)
R6	0Ω, 1/8W (2012)	Thick Film Resistor (5%)	Series Resistor for Signal Interface (VL)
R7	0Ω, 1/8W (2012)	Thick Film Resistor (5%)	Emitter Resistor for Switching (UH)
R8	0Ω, 1/8W (2012)	Thick Film Resistor (5%)	Emitter Resistor for Switching (VH)
R12	0Ω, 1/8W (2012)	Thick Film Resistor (5%)	Emitter Resistor for Switching (WH)
R16	10Ω, 1/8W	Carbon Film Resistor (5%)	Bootstrap Resistor
R17	1kΩ, 1/8W (2012)	Thick Film Resistor (5%)	Pull-Up Resistor (For LED)
C1	100nF, 25V (2012)	MLCC	+15V Bias Voltage Bypass Capacitor (U)
C2	100nF, 25V (2012)	MLCC	+15V Bias Voltage Bypass Capacitor (W)
C3	100nF, 25V (2012)	MLCC	+15V Bias Voltage Bypass Capacitor (V)
C4	0.1uF, 630V	Film Capacitor	Snubber Capacitor to Suppress the Spike-Voltage
C5	1nF, 25V (2012)	MLCC	High-Side Pull-down Capacitor (Phase U)
C6	1nF, 25V (2012)	MLCC	High-Side Pull-down Capacitor (Phase V)
C7	1nF, 25V (2012)	MLCC	High-Side Pull-down Capacitor (Phase W)
C8	1nF, 25V (2012)	MLCC	Low-Side Pull-down Capacitor (Phase U)
C9	1nF, 25V (2012)	MLCC	Low-Side Pull-down Capacitor (Phase V)
C10	1nF, 25V (2012)	MLCC	Low-Side Pull-down Capacitor (Phase W)
C14	1000nF, 25V (2012)	MLCC	Bypass Capacitor for Bootstrap Supply (Phase U)
C15	1000nF, 25V (2012)	MLCC	Bypass Capacitor for Bootstrap Supply (Phase V)
C16	10uF, 50V	Electrolytic Capacitor	+15V Bias Voltage Source Capacitor
C17	100nF, 25V (2012)	MLCC	+15V Bias Voltage Source Bypass Capacitor
C18	1000nF, 25V (2012)	MLCC	Bypass Capacitor for Bootstrap Supply (Phase W)
D1	1A, 600V	Fast Recovery Diode, (1N4937)	Bootstrap Diode (Phase U)
D2	1A, 600V	Fast Recovery Diode, (1N4937)	Bootstrap Diode (Phase V)
D3	1A, 600V	Fast Recovery Diode, (1N4937)	Bootstrap Diode (Phase W)
D4	Red LED	LED	+15V Display LED
U1	3A, 500V	Motion-SPM in Tiny-DIP	FSB50450

2.3 Printed Circuit Board

2.3.1 PCB Map



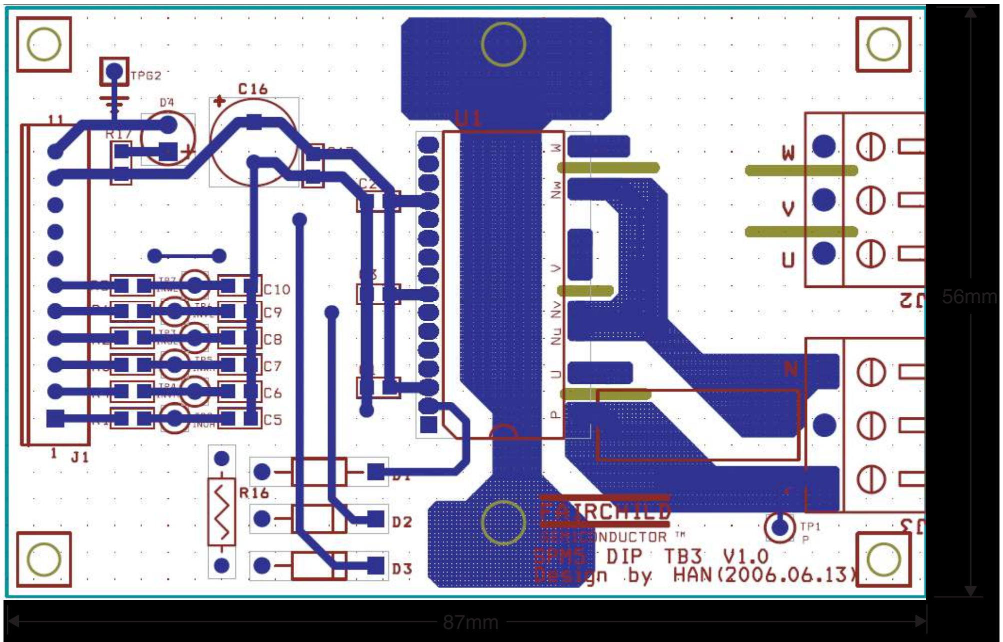
2.3.2 Circuit Layout Design

1. To avoid malfunction, the wiring of each input should be as short as possible. (less than 2–3cm)
2. All the by-pass capacitors and filter capacitors should be placed very close to SPM.
3. The isolation distance of DC-P, U-phase, V-phase, W-phase, DC-N/GND blocks should be over 2.54mm(100mil) for 300V~500V P-N voltage.
4. Power-GND and signal-GND should be connected with each other through only one 1.5~2mm width pattern.
5. To prevent surge destruction, the wiring between the filter capacitor and the P & Ground pins should be as short as possible. The use of a high frequency non-inductive capacitor of around 0.1~0.22μF between the P & Ground pins is recommended. In addition to reducing local voltage spikes, the placement and quality of this capacitor will have a direct impact on both conducted and radiated EMI.
6. To prevent over temperature destruction, the cooling is an important issue users have to be aware of, see Section 2.4.

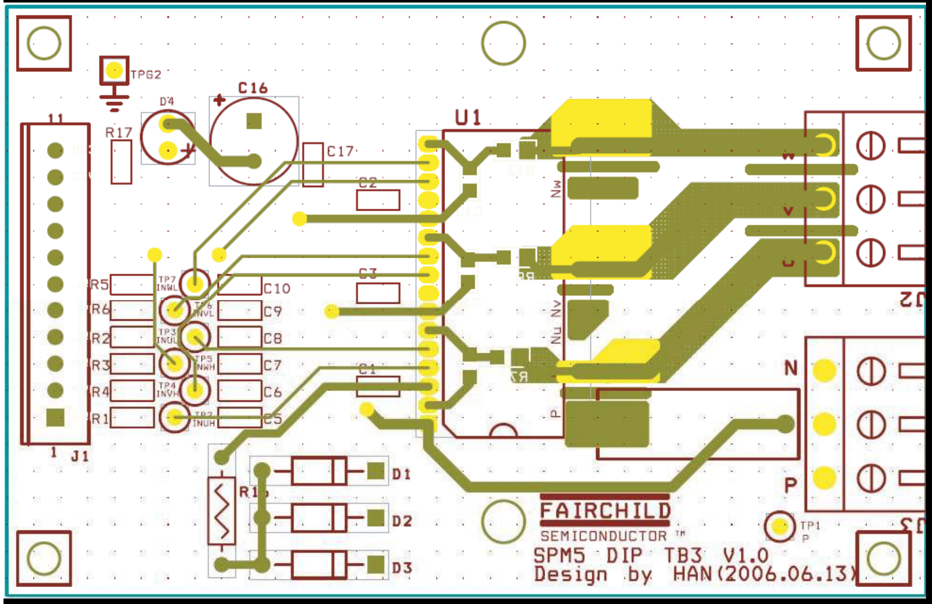
2.3.3 External Connection

Signal Interface (J1)		1	High-Side Input Signal from CPU (Phase U)
		2	High-Side Input Signal from CPU (Phase V)
		3	High-Side Input Signal from CPU (Phase W)
		4	Low-Side Input Signal from CPU (Phase U)
		5	Low-Side Input Signal from CPU (Phase V)
		6	Low-Side Input Signal from CPU (Phase W)
		7	NC
		8	NC
		9	NC
		10	SPM Bias Supply +15V Terminal
		11	SPM Bias Supply Ground Terminal
Power Interface	J3	P	Positive DC Link Input Connection
		N	Negative DC Link Input Connection
	J2	U	Motor Input Connection (Phase U)
		V	Motor Input Connection (Phase V)
		W	Motor Input Connection (Phase W)

2.3.4 Wiring of PCB



(a) Top Side View



(b) Bottom Side View

2.4 Recommended Cooling Method of Motion-SPM in Tiny-DIP

The TINY-DIP package is an extremely compact package for above 100W applications and this package does not contain a screw hole, and therefore, cooling and heat-sink installation are important elements of this design. Users must be careful.

Temperature rise of power semiconductors is due to the non-ideal effects of switching devices (IGBT, MOSFET and diode, etc). When the switching devices are turned on, there is a forward voltage drop which leads to Power Loss = (Conduction current) • (Voltage drop) and there are switching losses due to the finite rise and fall time of current and voltage during switching period. These total power losses in the devices make the case temperature rise with the thermal resistance of each package according to the below formula.

$T_J - T_C$ = Power Loss / Thermal Resistance

In order to decrease the case temperature and increase the SOA area, minimization of the total thermal resistance and power losses is required.

Heat-sink, which is one of the most popular cooling methods for power devices, contributes to the decrease of the thermal resistance. That is, heat-sink can improve the thermal performance by spreading and cooling the heat.

Everything with comparably high thermal conductivity can be heat-sink. For example, even PCB patterns can be heat-sink if it has enough cooling areas. Especially, TINY-DIP packages with no stand-off and SMD can benefit from cooling area of the bottom-side of the module on PCBs as the distance from the bottom of power modules and PCB is zero. Similarly, thicker pattern of power pins is also useful. Figure 1 (below) shows typical test board for Motion-SPMs in TINY-DIP package without a cooling area and Figure 2 shows test board with cooling area at bottom side of the module and thicker power pins. For cooling purposes, the bare copper area is preferable.

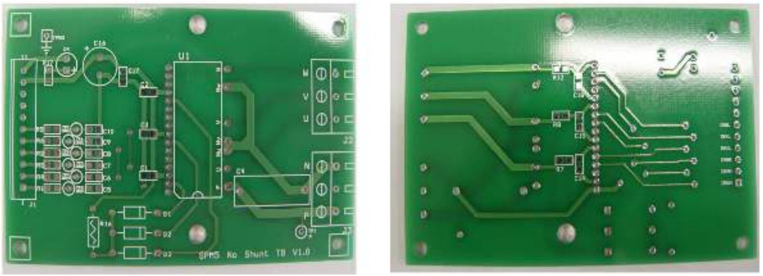


Figure 1. Test Board of Motion-SPM in Tiny-DIP without any Cooling Area

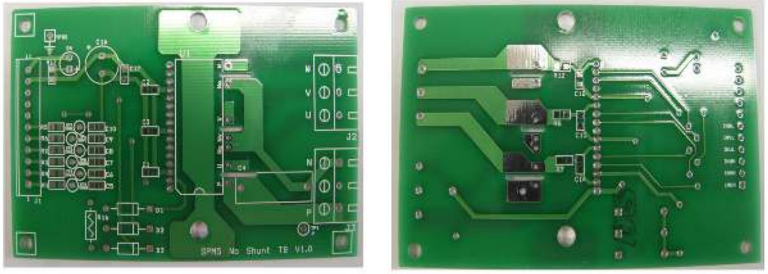


Figure 2. Test Board of Moition-SPM in Tiny-DIP with Cooling Area of Bottom Side and Thicker Power Pins

Because TINY-DIP-SPM doesn't have the screw hole, we recommend special heat-sink installation methods like Figure 3. Using the chassis for heat-sink like (a) in fig.3 seems to be effective at built-in applications. But in some cases, users can have difficulty in installing the heat-sink on DIP (Dual-in-line) package rather than SIP (Single-in-line) package. In this case, (c) in Figure 3 can be the probable solution. We can solve the problem by mechanically extending the tail of the heat-sink and fixing the tail on the chassis.

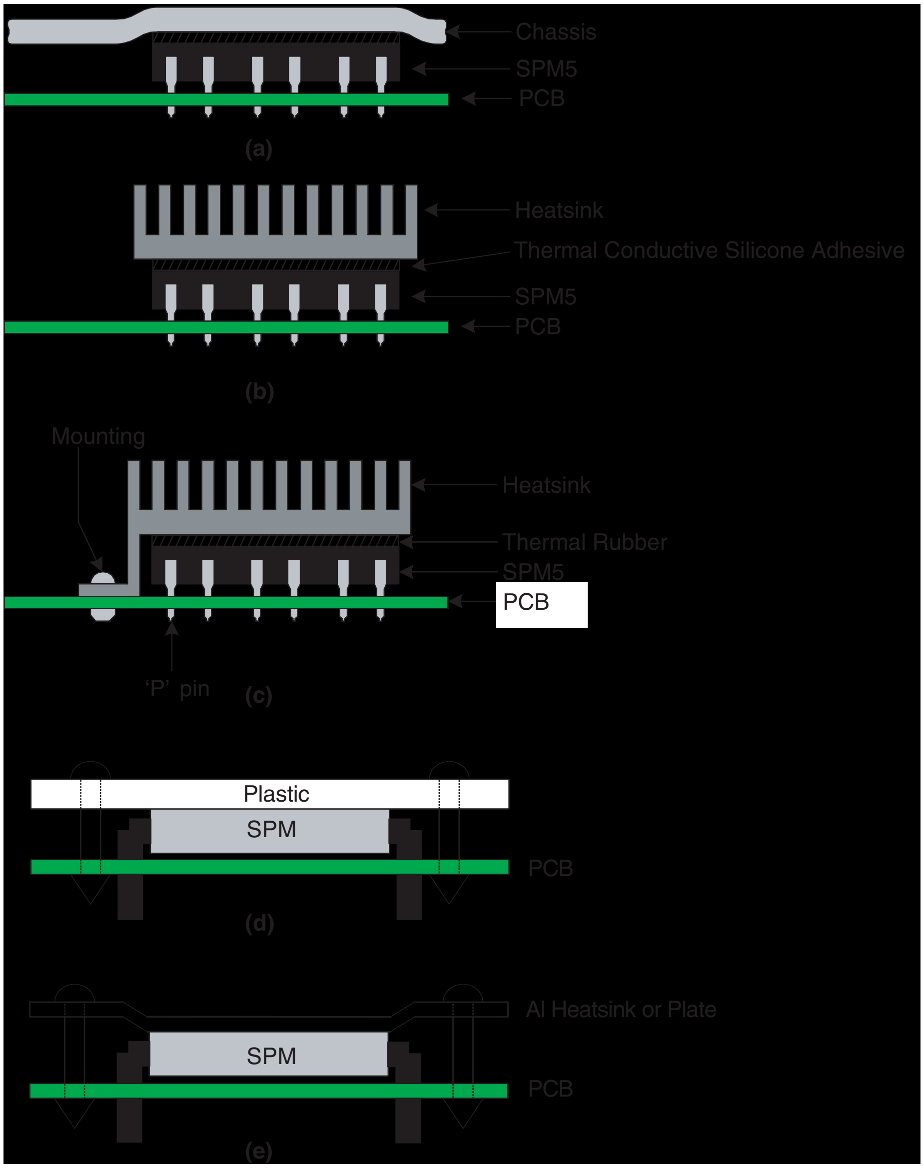


Figure 3. Heat-Sink Installation Method of Motion-SPM in Tiny-DIP

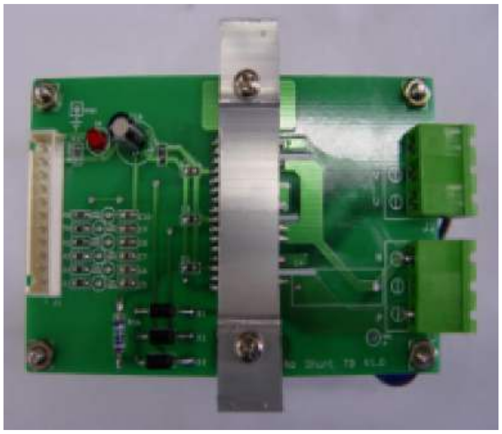


Figure 4. One Example of Heat-Sink Installation Using (e) from Figure 3

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