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FAN48617 Fixed-Output Synchronous TinyBoost® Regulator

Features

- Input Voltage Range: 2.7 V to 4.5 V
- Output Voltage: 5.0 V
- 1000 mA Max. Load Capability
- PWM Only
- Up to 97% Efficient
- Forced Pass-Through Operation via EN Pin
- Internal Synchronous Rectification
- True Load Disconnect
- Short-Circuit Protection
- External Components: 2016 (Metric) 1 μ H Inductor, 0402 Case Size Input / Output Capacitors

Applications

- Class-D Audio Amplifier
- Boost for Low-Voltage Li-Ion Batteries
- Smart Phones, Tablets, Portable Devices
- RF Applications
- NFC Applications

Description

The FAN48617 is a low-power PWM only boost regulator designed to provide a minimum voltage-regulated rail from a standard single-cell Li-Ion battery and advanced battery chemistries. Even below the minimum system battery voltage, the device maintains the output voltage regulation for an output load current of 1000 mA. The combination of built-in power transistors, synchronous rectification, and low supply current suit the FAN48617 for battery-powered applications.

The FAN48617 is available in a 9-bump, 0.4 mm pitch, (1.215 x 1.215 mm) Wafer-Level Chip-Scale Package (WLCSP).

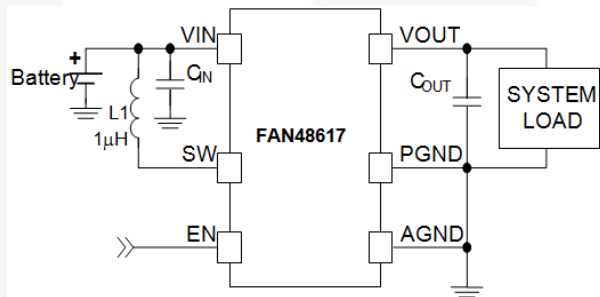


Figure 1. Typical Application

Ordering Information

Part Number	V _{OUT}	Operating Temperature	Package	Packing	Device Marking
FAN48617UC50X	5.0 V	-40°C to 85°C	9-Bump, 0.4 mm Pitch, WLCSP Package	Tape and Reel	K2

Block Diagram

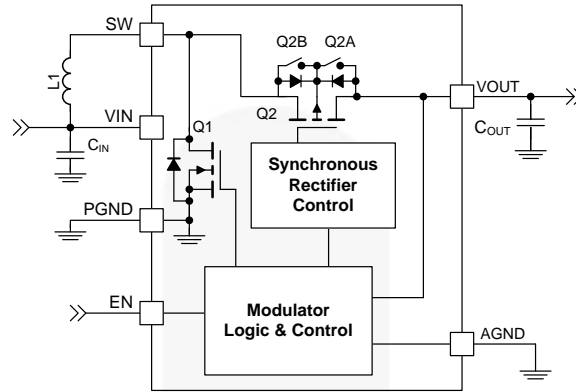


Figure 2. IC Block Diagram

Table 1. Recommended Components

Component	Description	Vendor	Parameter	Typ.	Unit
L1	20%, 3.9 A, 2016, 1.0 mm Height	DFE201610E-1R0M TOKO	Inductance	1	μH
			DCR (Series R)	48	mΩ
C _{IN}	20%, 6.3 V, X5R, 0402 (1005)	C1005X5R0J106M050BC TDK	Capacitance	10	μF
C _{OUT 1} ⁽¹⁾	20%, 6.3 V, X5R, 0402 (1005)	C1005X5R0J106M050BC TDK	Capacitance	2 x 10	
C _{OUT 2} ⁽²⁾	20%, 6.3 V, X5R, 0402 (1005)	C1005X5R0J106M050BC TDK	Capacitance	3 x 10	

Notes:

1. For applications with $I_{OUT} < 500$ mA use C_{OUT 1}.
2. For applications with 500 mA $\leq I_{OUT} < 1000$ mA use C_{OUT 2}.

Pin Configuration

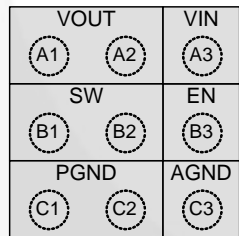


Figure 3. Top View

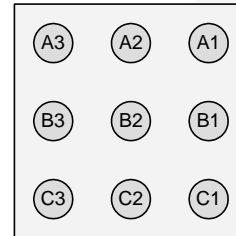


Figure 4. Bottom View

Pin Definitions

Pin #	Name	Description
A1, A2	VOUT	Output Voltage. This pin is the output voltage terminal; connect directly to C _{OUT} .
A3	VIN	Input Voltage. Connect to Li-Ion battery input power source and C _{IN} .
B1, B2	SW	Switching Node. Connect to inductor.
B3	EN	Enable. When this pin is HIGH, the circuit is enabled. After part is engaged, pin forces part into Forced-Pass-Through Mode when EN pin is pulled LOW.
C1, C2	PGND	Power Ground. This is the power return for the IC. C _{OUT} capacitor should be returned with the shortest path possible to these pins.
C3	AGND	Analog Ground. This is the signal ground reference for the IC. All voltage levels are measured with respect to this pin – connect to PGND at a single point.

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Symbol	Parameter		Min.	Max.	Unit
V_{IN}	Voltage on VIN Pin		-0.3	6.0	V
V_{OUT}	Voltage on VOUT Pin			6.0	V
V_{SW}	SW Node	DC	-0.3	6.0	V
		Transient: 10 ns, 3 MHz	-1.0	8.0	
V_{CC}	Voltage on Other Pins		-0.3	6.0 ⁽³⁾	V
ESD	Electrostatic Discharge Protection Level	Human Body Model, ANSI/ESDA/JEDEC JS-001-2012	2.0		kV
		Charged Device Model per JESD22-C101	1.0		
T_J	Junction Temperature		-40	+150	°C
T_{STG}	Storage Temperature		-65	+150	°C
T_L	Lead Soldering Temperature, 10 Seconds			+260	°C

Note:

3. Lesser of 6.0 V or $V_{IN} + 0.3$ V.

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fairchild does not recommend exceeding them or designing to absolute maximum ratings.

Symbol	Parameter	Min.	Max.	Unit
V_{IN}	Supply Voltage	2.7	4.5	V
I_{OUT}	Maximum Output Current	1000		mA
T_A	Ambient Temperature	-40	+85	°C
T_J	Junction Temperature	-40	+125	°C

Thermal Properties

Junction-to-ambient thermal resistance is a function of application and board layout. This data is measured with four-layer 2s2p boards with vias in accordance to JEDEC standard JESD51. Special attention must be paid not to exceed junction temperature, $T_{J(max)}$, at a given ambient temperature, T_A .

Symbol	Parameter	Typical	Unit
θ_{JA}	Junction-to-Ambient Thermal Resistance	50	°C/W

Electrical Specifications

Recommended operating conditions, unless otherwise noted, circuit per Figure 1, $V_{OUT} = 5.0\text{ V}$. Typical, minimum and maximum values are given at $V_{IN} = 3.6\text{ V}$, $T_A = 25^\circ\text{C}$, -40°C , and $+85^\circ\text{C}$.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Power Supply						
I_Q	V_{IN} Quiescent Current	$I_{OUT} = 0\text{ mA}$, $EN = 1.8\text{ V}$, No Switching		95		μA
		Forced Pass-Through $EN = 0\text{ V}$, $V_{OUT} = V_{IN}$		3.5		
V_{UVLO}	Under-Voltage Lockout	V_{IN} Rising		2.20		V
V_{UVLO_HYS}	Under-Voltage Lockout Hysteresis			150		mV
Inputs						
V_{IH}	Enable HIGH Voltage		1.05			V
V_{IL}	Enable LOW Voltage				0.4	V
Outputs						
V_{REG}	Output Voltage Accuracy DC ⁽⁴⁾	$2.7\text{ V} \leq V_{IN} \leq 4.5\text{ V}$	-2		+2	%
Timing						
f_{SW}	Switching Frequency	$I_{OUT} = 300\text{ mA}$	1.8	2.3	2.8	MHz
$t_{SS}^{(5)}$	EN HIGH to 95% of Regulation	$I_{OUT} = 150\text{ mA}$		425		μs
$t_{RST}^{(5)}$	FAULT Restart Timer			20		ms
Power Stage						
$R_{DS(ON)N}$	N-Channel Boost Switch $R_{DS(ON)}$			63		m Ω
$R_{DS(ON)P}$	P-Channel Sync. Rectifier $R_{DS(ON)}$			52		m Ω

Notes:

- DC I_{LOAD} from 0 to 1000 mA. V_{OUT} measured from mid-point of output voltage ripple. Effective capacitance of $C_{OUT} \geq 6.3\text{ }\mu\text{F}$.
- Guaranteed by design and characterization; not tested in production.

Typical Performance Characteristics

Unless otherwise specified; $V_{IN} = 3.6\text{ V}$, $V_{OUT} = 5.0\text{ V}$, $T_A = 25^\circ\text{C}$, and circuit according to Figure 1.
 Components: $C_{IN} = 10\ \mu\text{F}$, $C_{OUT} = 3 \times 10\ \mu\text{F}$ (0402, X5R, 6.3 V, C1005X5R0J106M050BC), $L1 = 1\ \mu\text{H}$ (2016, 48 m Ω , DFE201610E-1R0M).

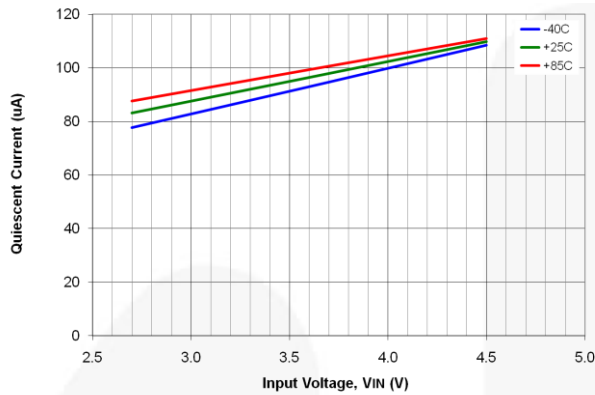


Figure 5. Quiescent Current (No Switching) vs. Input Voltage and Temperature

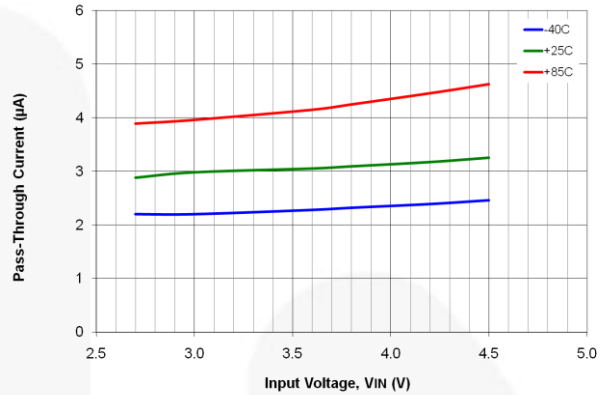


Figure 6. Pass-Through Current vs. Input Voltage and Temperature

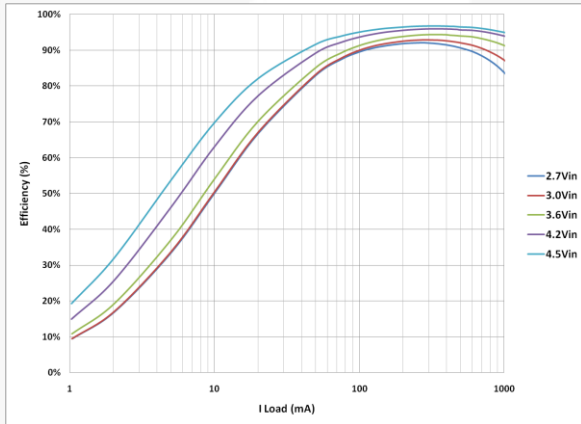


Figure 7. Efficiency vs. Load Current and Input Voltage

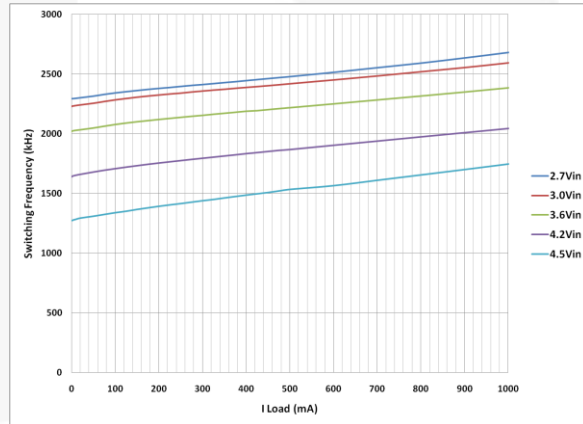


Figure 8. Switching Frequency vs. Load Current and Input Voltage

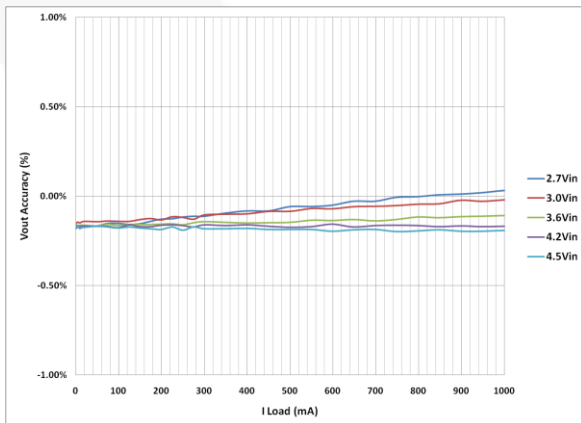


Figure 9. Output Regulation vs. Load Current and Input Voltage

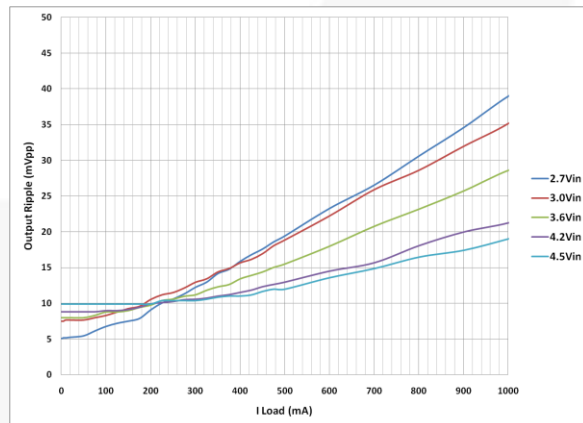


Figure 10. Output Ripple vs. Load Current and Input Voltage

Typical Performance Characteristics

Unless otherwise specified; $V_{IN} = 3.6\text{ V}$, $V_{OUT} = 5.0\text{ V}$, $T_A = 25^\circ\text{C}$, and circuit and components according to Figure 1. Components: $C_{IN} = 10\ \mu\text{F}$, $C_{OUT} = 3 \times 10\ \mu\text{F}$ (0402, X5R, 6.3 V, C1005X5R0J106M050BC), $L1 = 1\ \mu\text{H}$ (2016, 48 m Ω , DFE201610E-1R0M).

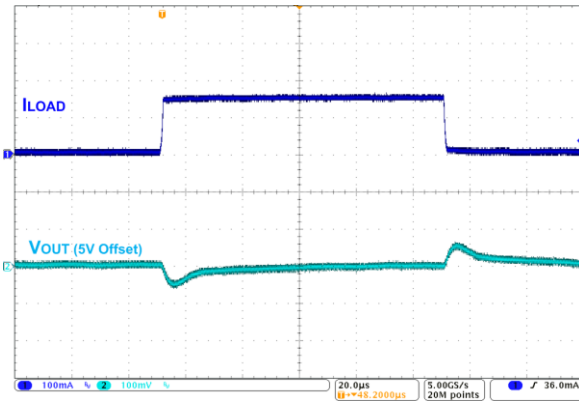


Figure 11. Load Transient, 10 \leftrightarrow 150 mA, 1 μs Edge

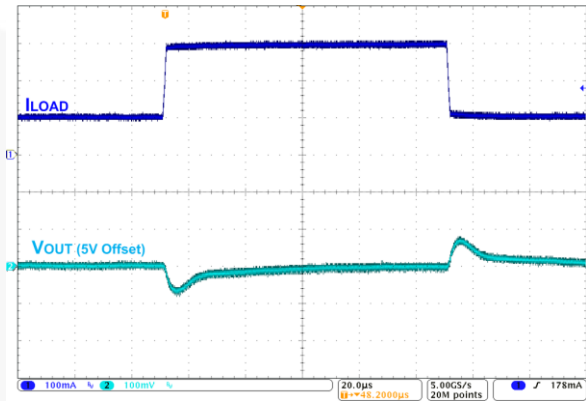


Figure 12. Load Transient, 100 \leftrightarrow 300 mA, 1 μs Edge

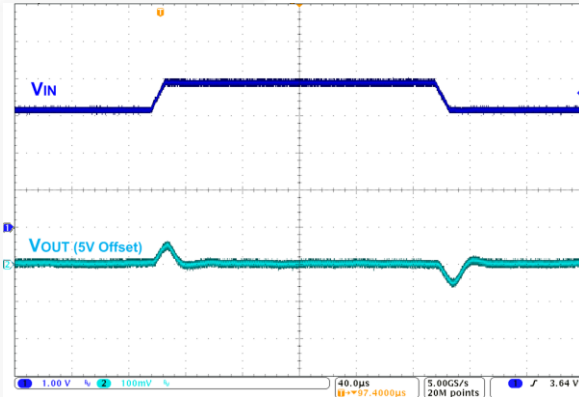


Figure 13. Line Transient, 3.2 V \leftrightarrow 3.9 V, 10 μs Edge, 150 mA Load

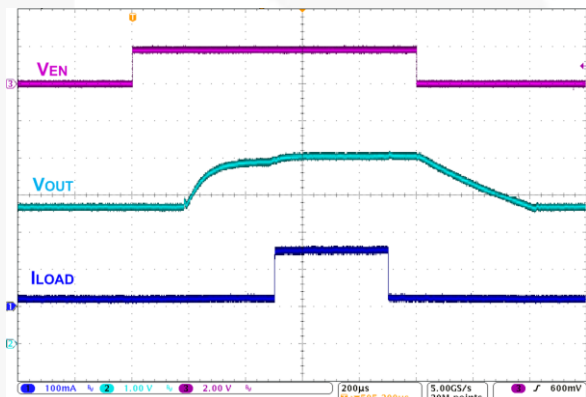


Figure 14. Pass-Through Mode \leftrightarrow Boost Mode with Load Transient, 20 \leftrightarrow 150 mA, 1 μs Edge

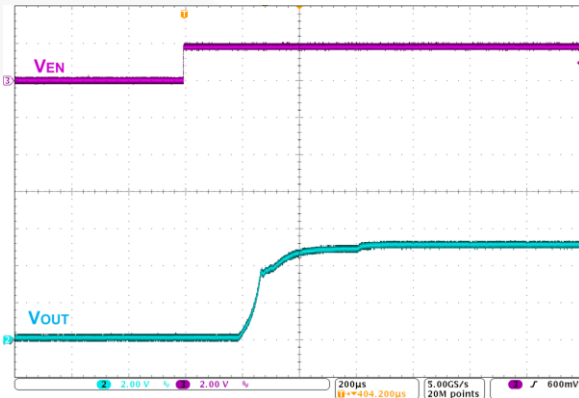


Figure 15. Startup, 150 mA Load

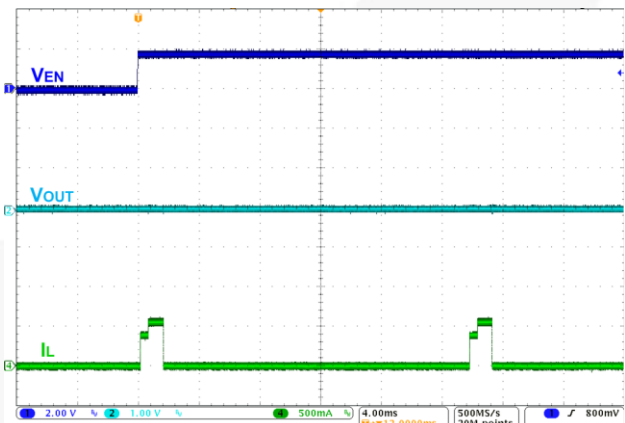


Figure 16. Fault Restart

Circuit Description

FAN48617 is a synchronous PWM Only boost regulator. The regulator's Pass-Through Mode automatically activates when V_{IN} is above the boost regulator's set point.

Table 2. Operating Modes

Mode	Description	Invoked When:
LIN	Linear Startup	$V_{IN} > V_{OUT}$
SS	Boost Soft-Start	$V_{IN} < V_{OUT} < V_{OUT(TARGET)}$
BST	Boost Operating Mode	$V_{OUT} = V_{OUT(TARGET)}$
PT	Pass-Through Mode	$V_{IN} > V_{OUT(TARGET)}$ OR when EN is pulled LOW after initial startup

Boost Mode Regulation

The FAN48617 uses a current-mode modulator to achieve excellent transient response.

Table 3. Boost Startup Sequence

Start Mode	Entry	Exit	End Mode	Timeout (μs)
LIN1	$V_{IN} > V_{UVLO}$, EN=1	$V_{OUT} > V_{IN} - 300\text{ mV}$	SS	
		Timeout	LIN2	512
LIN2	LIN1 Exit	$V_{OUT} > V_{IN} - 300\text{ mV}$	SS	
		Timeout	FAULT	1024
SS	LIN1 or LIN2 Exit	$V_{OUT} = V_{OUT(TARGET)}$	BST	
		Overload Timeout	FAULT	64

LIN Mode

When EN is HIGH and $V_{IN} > V_{UVLO}$, the regulator first attempts to bring V_{OUT} within 300 mV of V_{IN} by using the internal fixed-current source from V_{IN} (Q2). The current is limited to the LIN1 set point.

If V_{OUT} reaches $V_{IN} - 300\text{ mV}$ during LIN1 Mode, the SS Mode is initiated. Otherwise, LIN1 times out after 512 μs and LIN2 Mode is entered.

In LIN2 Mode, the current source is incremented. If V_{OUT} fails to reach $V_{IN} - 300\text{ mV}$ after 1024 μs, a fault condition is declared and the device waits 20 ms to attempt an automatic restart.

Soft-Start (SS) Mode

Upon the successful completion of LIN Mode ($V_{OUT} \geq V_{IN} - 300\text{ mV}$), the regulator begins switching with boost pulses current limited to 50% of nominal level.

During SS Mode, if V_{OUT} fails to reach regulation during the SS ramp sequence for more than 64 μs, a fault is declared. If large C_{OUT} is used, the reference is

automatically stepped slower to avoid excessive input current draw.

Boost (BST) Mode

This is a normal operating mode of the regulator.

Pass-Through (PT) Mode

The device allows the user to force the device in Forced Pass-Through Mode through the EN pin. If the EN pin is pulled HIGH, the device starts operating in Boost Mode. Once the EN pin is pulled LOW, the device is forced into Pass-Through Mode. To disable the device, the input supply voltage must be removed. The device cannot startup in Forced Pass-Through Mode (see Figure 17). During startup, keep the EN pulled HIGH for at least 350 μs before pulling it LOW in order to make sure that the device enters Pass-Through Mode reliably

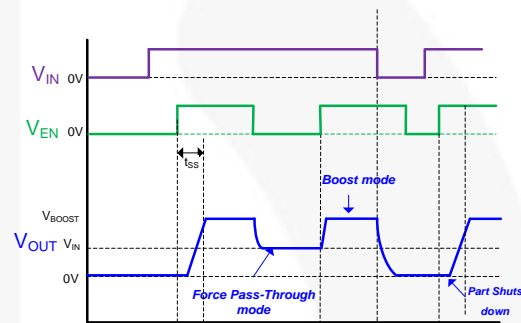


Figure 17. Pass-Through Profile

Current Limit Protection

The FAN48617 has valley current limit protection in case of overload situations. The valley current limit will prevent high current from causing damage to the IC and the inductor. The current limit is halved during soft-start.

When starting into a fault condition, the input current will be limited by LIN1 and LIN2 current threshold.

Fault State

The regulator enters Fault State under any of the following conditions:

- V_{OUT} fails to achieve the voltage required to advance from LIN Mode to SS Mode.
- V_{OUT} fails to achieve the voltage required to advance from SS Mode to BST Mode.
- Boost current limit triggers for 2 ms during BST Mode.
- $V_{IN} - V_{OUT} > 300\text{ mV}$; this fault can occur only after successful completion of the soft-start sequence.
- $V_{IN} < V_{UVLO}$.

Once a fault is triggered, the regulator stops switching and presents a high-impedance path between V_{IN} and V_{OUT} . After waiting 20 ms, an automatic restart is attempted.

Over-Temperature

The regulator shuts down if the die temperature exceeds 150°C and restarts when the IC cools by ~20°C.

Application Information

Output Capacitance (C_{OUT})

The effective capacitance ($C_{EFF}^{(6)}$) of small, high-value ceramic capacitors decreases as their bias voltage increases, as illustrated in the graph below:

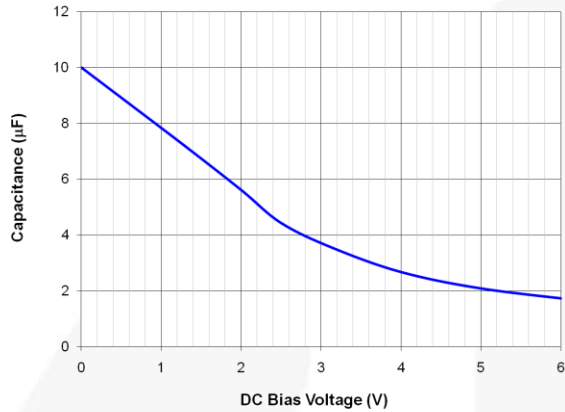


Figure 18. C_{EFF} for 10 μ F, 0402, X5R, 6.3 V-Rated Capacitor (TDK C1005X5R0J106M050BC)

FAN48617 is guaranteed for stable operation with the minimum value of C_{EFF} ($C_{EFF(MIN)}$) outlined in Table 4.

Table 4. Minimum C_{EFF} Required for Stability

Operating Conditions			$C_{EFF(MIN)}$ (μ F)
V_{OUT} (V)	V_{IN} (V)	I_{LOAD} (mA)	
5.0	2.7 to 4.5	0 to 500	4.2
5.0	2.7 to 4.5	0 to 1000	6.3

Note:

- C_{EFF} varies by manufacturer, capacitor material, and case size.

The table below pertains to MOD drawing on the following page.

Product-Specific Package Dimensions

Product	D	E	X	Y
FAN48617UC50X	1.215 \pm 0.030 mm	1.215 \pm 0.030 mm	0.2075 mm	0.2075 mm

Layout Recommendations

The layout recommendations below highlight various top-copper pours by using different colors.

To minimize spikes at V_{OUT} , C_{OUT} must be placed as close as possible to PGND and V_{OUT} , as shown in Figure 19.

For best thermal performance, maximize the pour area for all planes other than SW. The ground pour, especially, should fill all available PCB surface area and be tied to internal layers with a cluster of thermal vias.

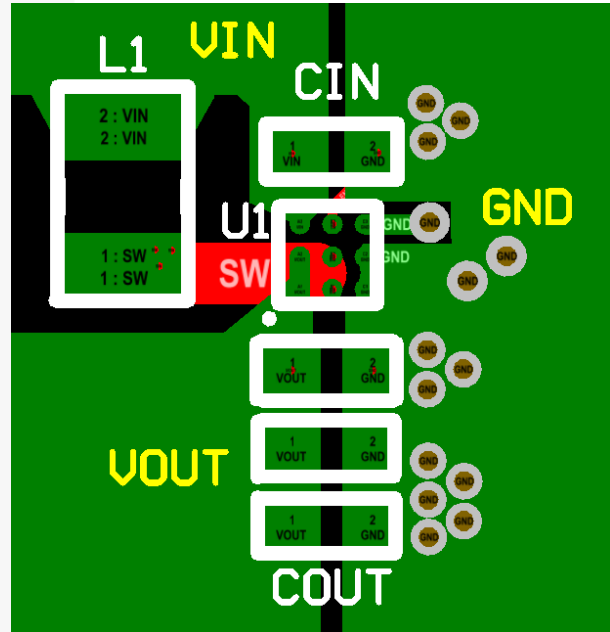
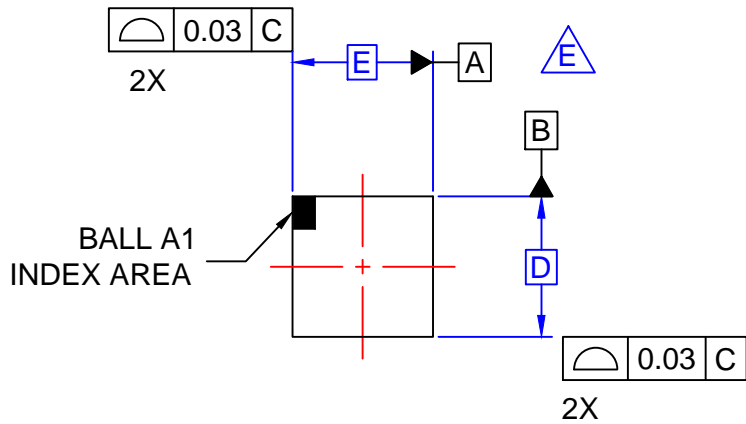
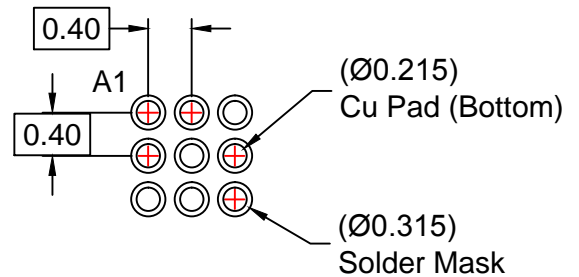


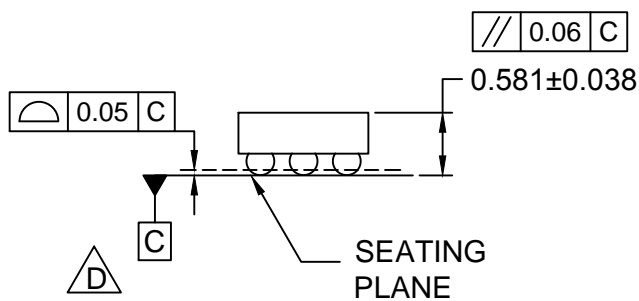
Figure 19. Layout Recommendation



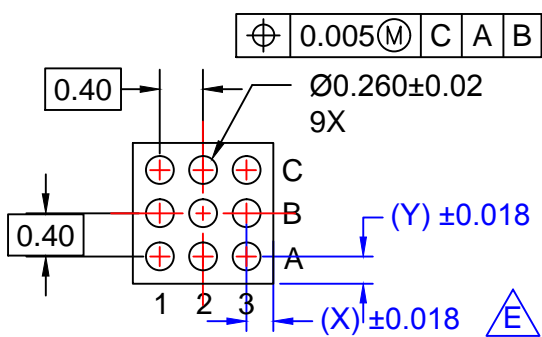
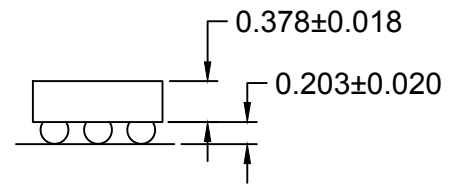
TOP VIEW



RECOMMENDED LAND PATTERN
(NSMD PAD TYPE)



SIDE VIEWS



BOTTOM VIEW

NOTES

- A. NO JEDEC REGISTRATION APPLIES.
- B. DIMENSIONS ARE IN MILLIMETERS.
- C. DIMENSIONS AND TOLERANCE PER ASME Y14.5M, 2009.
- D. DATUM C IS DEFINED BY THE SPHERICAL CROWNS OF THE BALLS.
- E. FOR DIMENSIONS D, E, X, AND Y SEE PRODUCT DATASHEET.
- F. DRAWING FILNAME: MKT-UC009Ak rev3

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