High Efficiency Single Inductor Auto Buck-Boost Converter

Features

- **2.55V ~ 5.5V Input Voltage Operation**
- **Adjustable Output Voltage from 2.8V to 5.5V**
- **96% Efficiency DC/DC Converter**
- **3A Output Current at 3.3V for VIN > 3.6V**
- **Auto-Transition Between Buck and Boost Mode**
- **Pulse-Skipping Mode at light load for Efficiency**
- **DC/DC Converter can be set to lower quiescent current at light load**
- **Fixed 2.4MHz Frequency and Synchronization Possible**
- **Internal Soft-Start**
- **Built-In Cycle-by Cycle Current Limit and Over Voltage Protection**
- **Built-In Thermal Shutdown Function**
- **Power Good Function**
- **TDFN3X4-14 Package (3mmx4mm)**

General Description

The M2224 is a high efficiency single inductor Buck-Boost converter which can supply the load current up to 4A. It provides auto-transition between Buck and Boost Mode. The M2224 operates at 2.4MHz and it can also be synchronized with external frequency from 2.2MHz to 2.6MHz. DC/DC converter operates at Pulse-Skipping Mode at light load. The Power Save Mode can be disabled, forcing the M2224 to operate at FPWM Mode. The output voltage is programmable using an external resistor divider, or is fixed to 3.3V internally. The load is disconnected from the VIN during shutdown.

The M2224 is available in TDFN3X4-14 package.

Applications

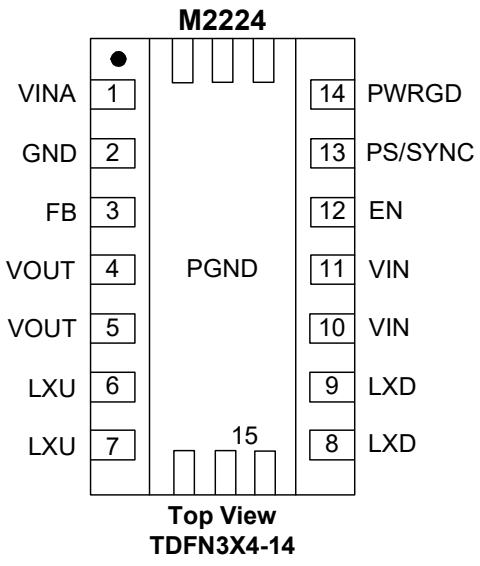
- **Mobile Handsets**
- **Smart Phone**

Ordering Information

ORDER NUMBER	MARKING	TEMP. RANGE	PACKAGE (Green)
M2224KH1U	2224	-40°C~+85°C	TDFN3X4-14

Note: KH: TDFN3X4-14
1: Bonding code
U: Tape & Reel
Green : Lead Free / Halogen Free.

Pin Configuration



Top View
TDFN3X4-14

Absolute Maximum Ratings

VIN, VINA, VOUT . . . . . -0.3V to +6.5V
LXD, LXU . . . . . -0.3V to +6.5V
EN, FB, PWRGD, PS/SYNC . . . . . -0.3V to +6.5V
Thermal Resistance Junction to Ambient, (θ_{JA})*
TDFN3X4-14 . . . . . 33.3°C/W
Continuous Power Dissipation (T_A=25°C)*
TDFN3X4-14. . . . . .3.75W
Thermal Resistance Junction to Case, (θ_{JC})
TDFN3X4-14 . . . . . .3.6°C/W
Operating Ambient Temperature . . . . . -35°C to 85°C
Storage Temperature Range. . . . . -55°C to +150°C
Reflow Temperature (soldering, 10 sec) . . . . . 260°C
ESD (HBM). 2kV
ESD (MM). 200V

*The package is placed on a 2-layer PCB. Please refer the “Board Layout”.

1. Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications are not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
2. Device is ESD sensitive. Handling precaution recommended. The Human Body model is a 100pF capacitor discharged through a 1.5KΩ resistor into each pin.

Electrical characteristics

(VIN=VINA=3.6V, T_A=25°C, unless otherwise specified)

The device is not guaranteed to function outside its operating conditions. Parameters with MIN and/or MAX limits are 100% tested at +25ºC, unless otherwise specified.

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
GENERAL						
VIN minimum Startup Voltage	$V_{IN,ST}$		---	---	2.7	V
VIN Operating Voltage	V_{IN}		2.55	---	5.5	V
Output Voltage Range	V_{OUT}		2.8	---	5.5	V
Under Voltage Lockout Threshold	$V_{UVLO,R}$	V_{INA} voltage rising	---	2.5	---	V
	$V_{UVLO,F}$	V_{INA} voltage falling	---	2.35	---	V
Quiescent Current	I_Q	V_{EN}=V_{IN}=V_{INA}=3.6V, I_{OUT}=0A (No Switching)	---	40	65	μA
Shutdown Current	I_{SD}	V_{EN}=0V, V_{IN}=V_{INA}=3.6V	---	0.1	1	μA
OSCILLATOR						
Oscillator Frequency	F_{OSC}		2.2	2.4	2.6	MHz
Frequency range for Synchronization	F_{SYN}		4.4	4.8	5.2	MHz
DCDC Converter						
Soft-Start Internal	SS	V_{IN}=V_{INA}=3.6V	---	0.5	---	ms
Feedback voltage	V_{FB}	Adjustable Output (FPWM)	495	500	505	mV
Output voltage		Fixed 3.3V Output (FPWM)	3.267	3.3	3.333	V
Line Regulation	$\Delta V_{OUT,LINE}$	FPWM	---	0.5	---	%
Load Regulation	$\Delta V_{OUT,LOAD}$	FPWM	---	0.5	---	%
Maximum Duty Cycle	$D_{MAX,D}$	LXD	---	100	---	%
	$D_{MAX,U}$	LXU	90	93	96	%
FB Leakage Current	$I_{FB,LK}$	Adjustable Mode	---	---	1	μA
VOUT Leakage Current	$I_{VO,LK}$	V_{LXU}=0V, VOUT=5V	---	1	5	μA
LXD, LXU Leakage Current	$I_{LXD,LK}$ $I_{LXU,LK}$	V_{LXD}=V_{LXU}=5V	---	1	5	μA
Switch ON Resistance	$R_{ON,P}$	V_{IN}=V_{INA}=3.6V	---	50	---	mΩ
	$R_{ON,N}$	V_{IN}=V_{INA}=3.6V	---	50	---	

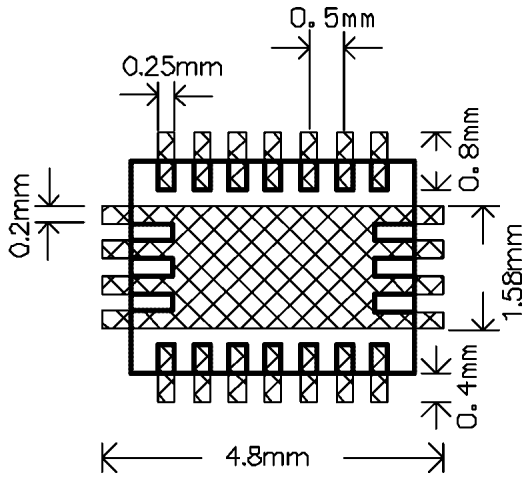
Electrical characteristics (continued)

The device is not guaranteed to function outside its operating conditions. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified.

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Peak Current Limit	I_{LIM}	V_{IN}=V_{INA}=3.6V	---	5	---	A
Protection						
Over Voltage Protection Threshold	%V_{OVP}	Ratio=V_{OVP}/V_{OUT}, V_{OUT} voltage rising	---	120	---	%
Short Circuit Protection threshold	%V_{SCP}	Ratio=V_{SCP}/V_{OUT}, V_{OUT} voltage falling	---	20	---	%
Thermal Shutdown Protection	T_{SD}		---	150	---	°C
Thermal Shutdown Hysteresis	ΔT_{SD}		---	20	---	°C
Control Signal						
EN, PS/SYNC Input Voltage	V_{TH}	High Threshold	1.2	---	---	V
	V_{TL}	Low Threshold	---	---	0.4	V
EN, PS/SYNC Leakage Current	$I_{EN,LK}$	EN=V_{INA} or 0V	---	---	1	μA
	$I_{PS/SYNC,LK}$	PS/SYNC= V_{INA} or 0V				
PWRGD Open-Drain Low Voltage	$V_{PG,LOW}$	I_{SINK}=10uA, V_{OUT}=3.3V	---	40	400	mV
PWRGD Open-Drain Leakage Current	$I_{PG,LK}$	V_{PG}=5V	---	---	1	μA
PWRGD Rising Threshold	$V_{OUT,PGH}$	Ratio=V_{OUT}/$V_{OUT,SET}$	---	95	---	%

Minimum Footprint PCB Layout Section

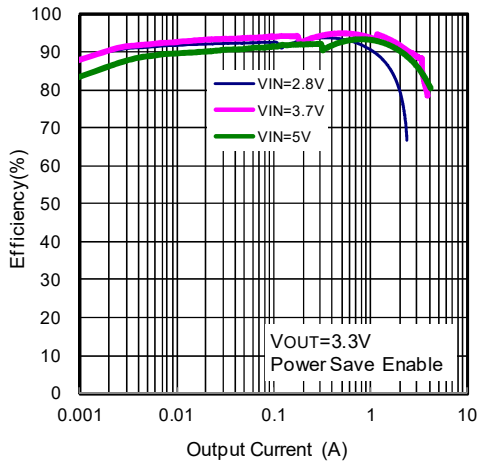
TDFN3X4-14



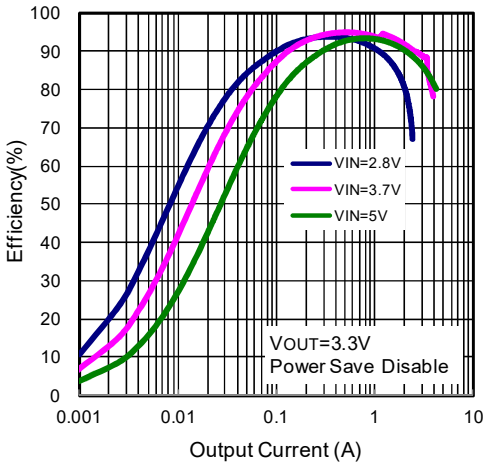
Typical Performance Characteristics

T_A=25°C.

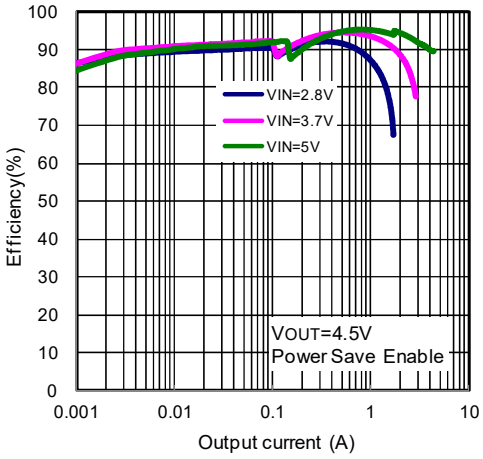
Efficiency vs. Output Current



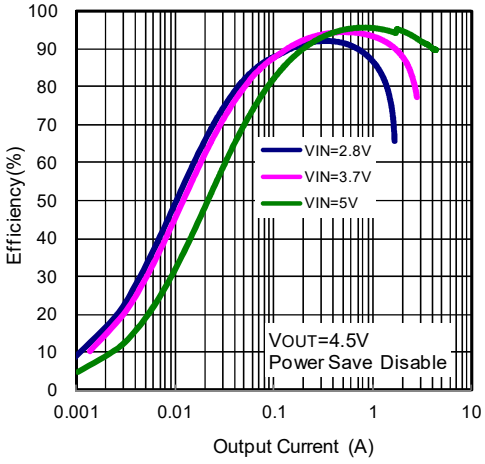
Efficiency vs. Output Current



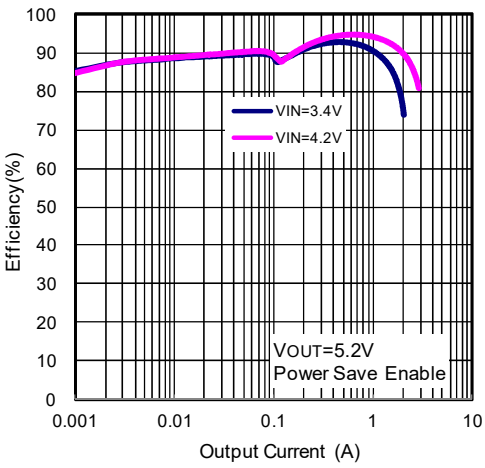
Efficiency vs. Output Current



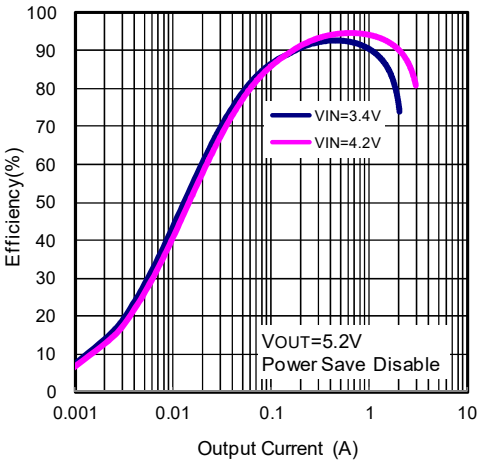
Efficiency vs. Output Current



Efficiency vs. Output Current



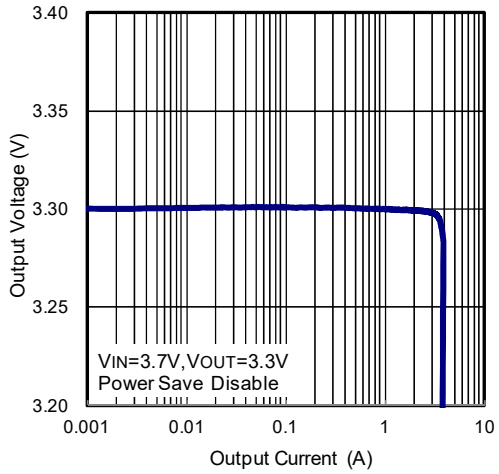
Efficiency vs. Output Current



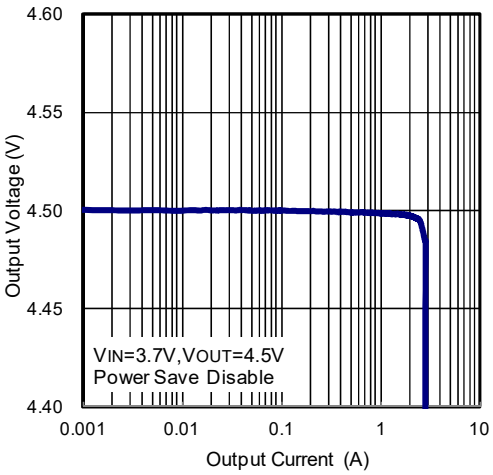
Typical Performance Characteristics (Continued)

T_A=25°C.

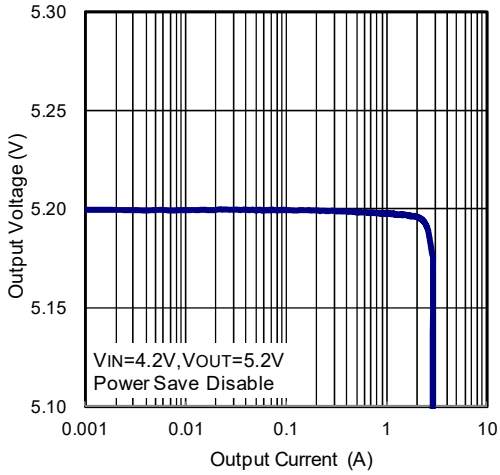
Output Voltage vs. Output Current



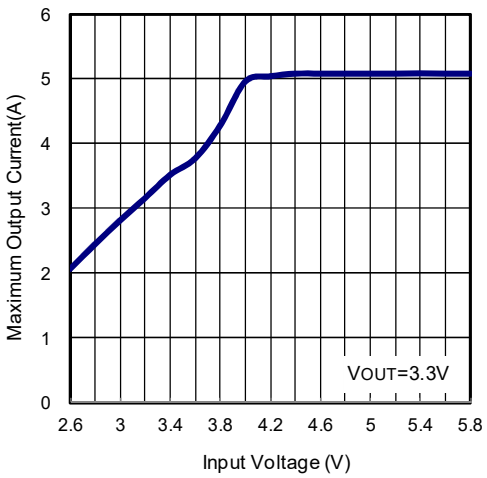
Output Voltage vs. Output Current



Output Voltage vs. Output Current



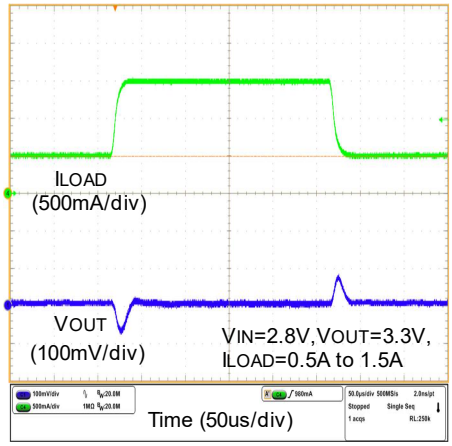
Maximum Output Current vs. Input Voltage



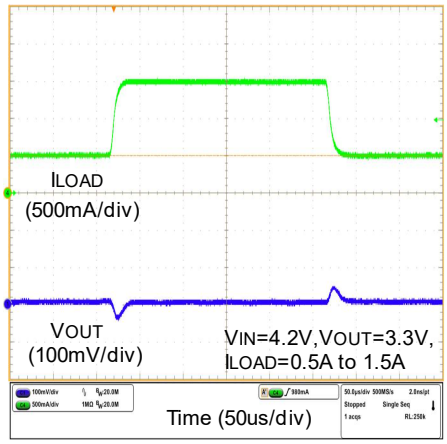
Typical Performance Characteristics (Continued)

T_A=25°C.

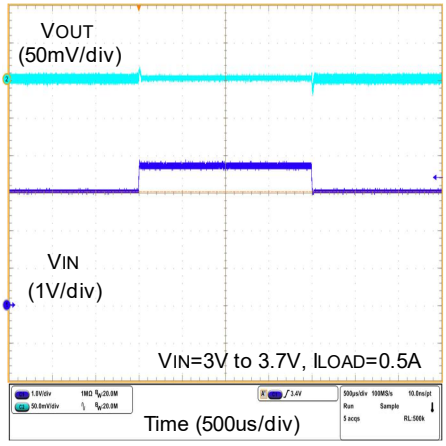
Load Transient Response



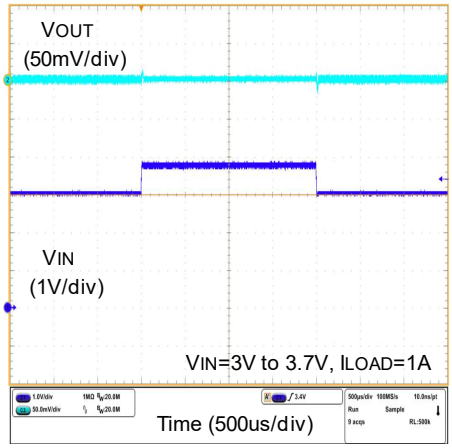
Load Transient Response



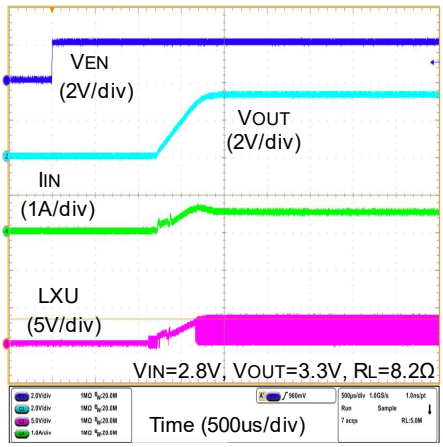
Line Transient Response



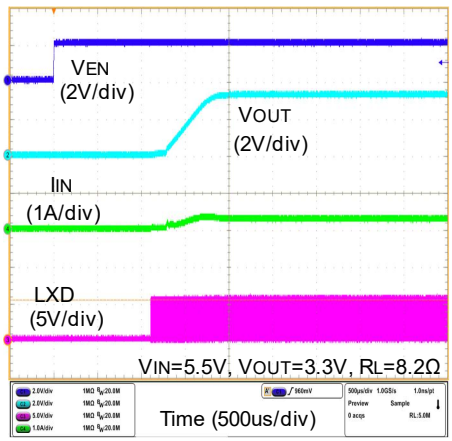
Line Transient Response



Start up After Enable



Start up After Enable

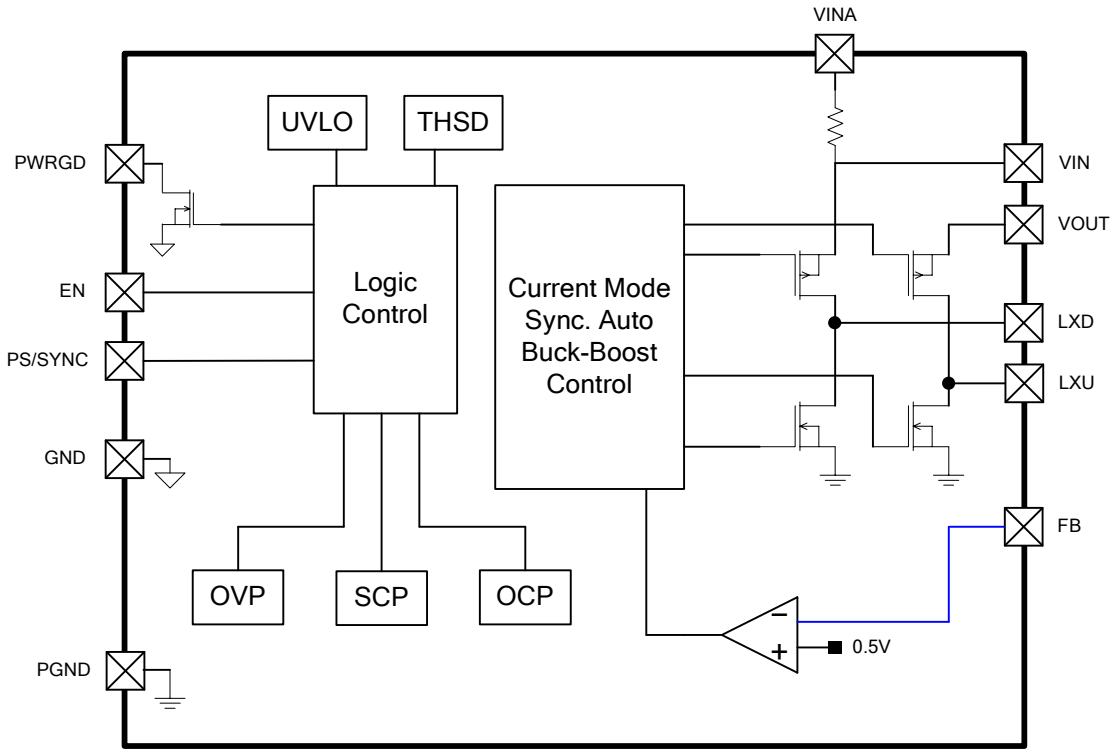


Pin Description

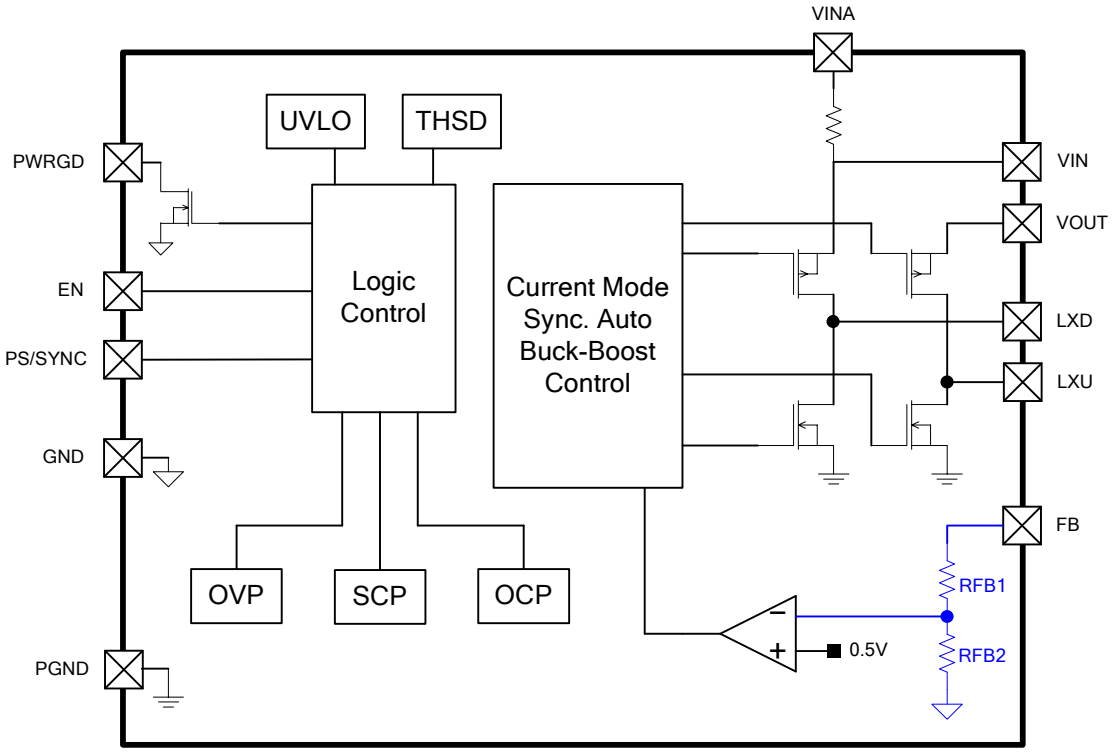
Pin No	Pin Name	Function
1	VINA	IC Power Supply Input
2	GND	Chip Analog Ground
3	FB	Voltage Feedback of Adjustable versions, must be connected to VOUT on fixed output voltage versions.
4, 5	VOUT	Power Output of Buck-Boost Converter
6, 7	LXU	Inductor Switch Node
8, 9	LXD	Inductor Switch Node
10, 11	VIN	Power Input of Buck-Boost Converter
12	EN	Enable PIN (1 Enabled, 0 Disabled), must not be left open.
13	PS/SYNC	Enable/Disable Power Save Mode (1 Disabled, 0 Enabled, clock signal for synchronization), must not be left open.
14	PWRGD	Indicator of Power Good with open drain output (1 Good, 0 Failure)
15 (EP)	PGND	Power Ground of Buck-Boost Converter. The exposed pad must be soldered to a large PCB and connected to PGND for maximum power dissipation.

Block Diagram

Adjustable Output Voltage

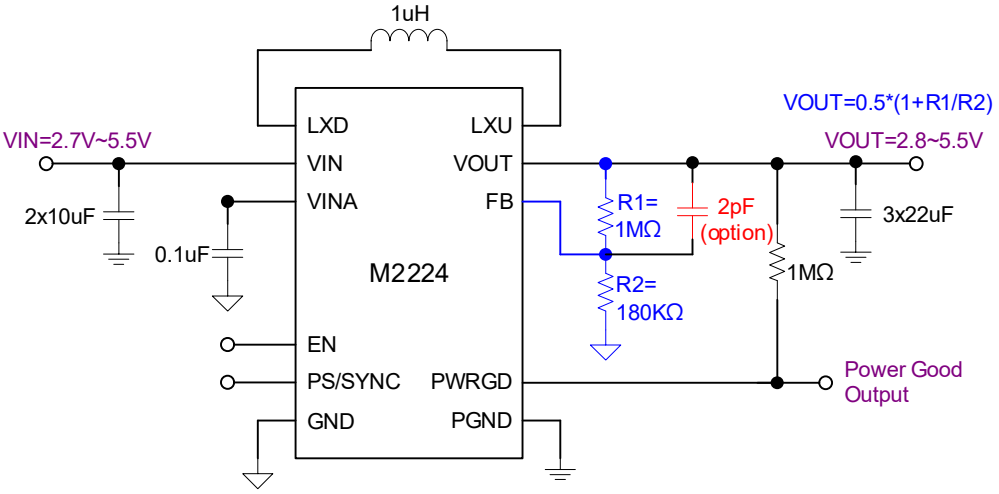


Fixed 3.3V Output Voltage



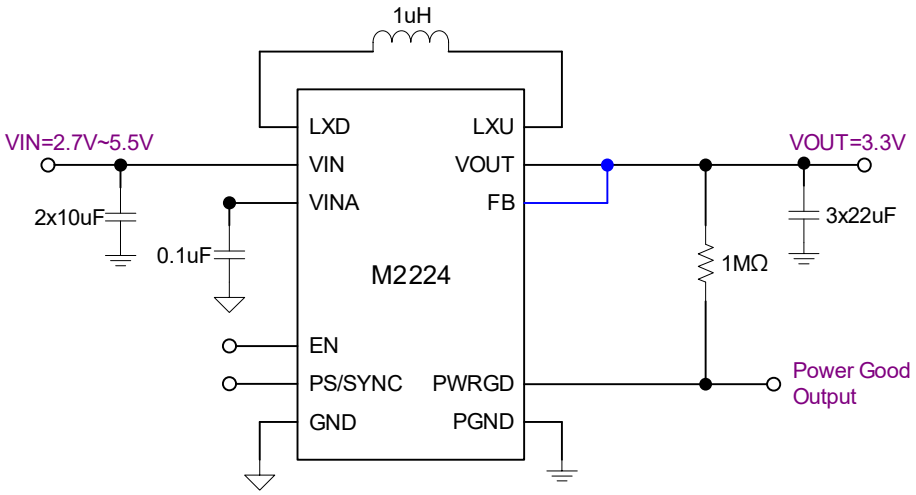
Application Circuit

Adjustable Output Voltage



The recommended value for R2 should be in the range of 150kΩ.

Fixed 3.3V Output Voltage



Function Description

The M2224 includes a DC/DC Converters.

	Topology	Default V_{OUT}	V_{OUT} range	Current rating
DCDC1	2.4MHz Sync. Auto Buck-Boost Converter	3.3V	Adjustable Mode: 2.8V to 5.5V	4A
			Fixed Mode: 3.3V	

Fault Protection

M2224 provides VIN under-voltage lockout protection, over-current protection, VOUT over-voltage protection, VOUT short-circuit protection, and thermal shutdown protection to achieve complete protection.

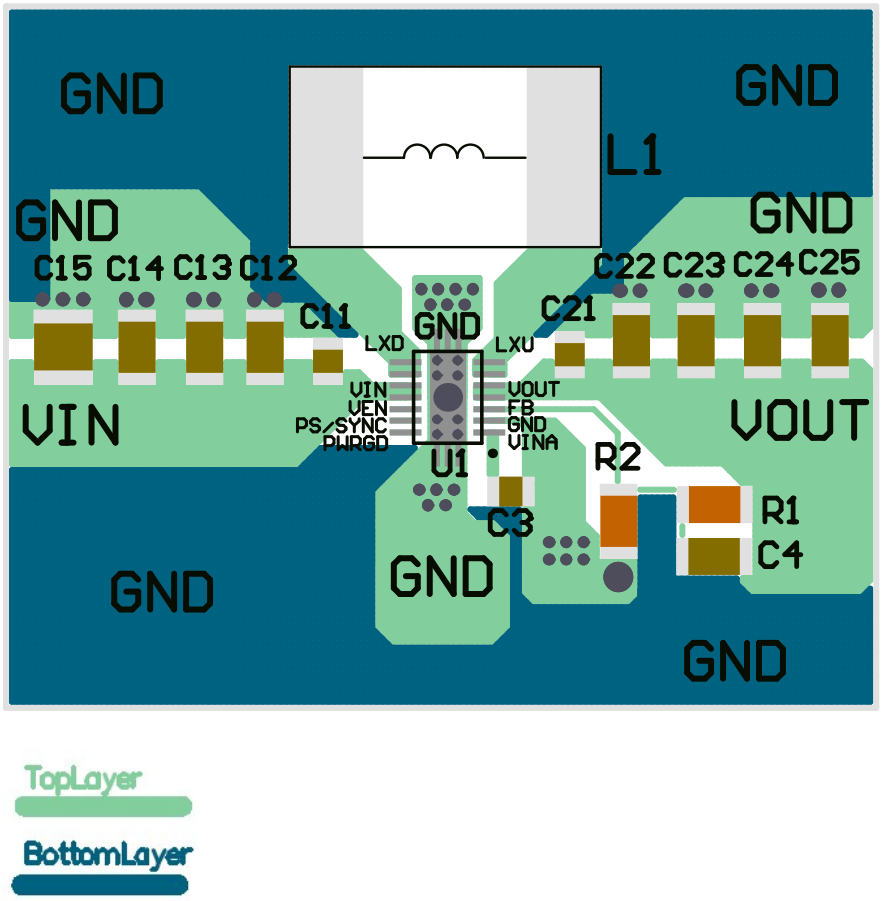
	Protection type	Threshold	Protection methods	Reset Method
VIN	UVLO	VIN<2.35V	DCDC1 shutdown	VIN>2.5V
DCDC1 Buck-Boost	Current Limit	Peak Inductor current>5A	Buck Mode: PMOS Off, NMOS on	Automatic Reset at next cycle
			Boost Mode: NMOS Off, PMOS on	
	OVP	VOUT>120%*$VOUT_{SET}$	DCDC1 stop switching	VOUT1<110%*$VOUT_{SET}$
	SCP	VOUT<20%*$VOUT_{SET}$	Current Limit = 2A OSC Frequency=1.2MHz	VOUT>30%*$VOUT_{SET}$
Thermal	TSD	Junction Temp. >150°C	DCDC1 shutdown	Junction Temp. <130°C

Layout Considerations

PCB Layout Guide

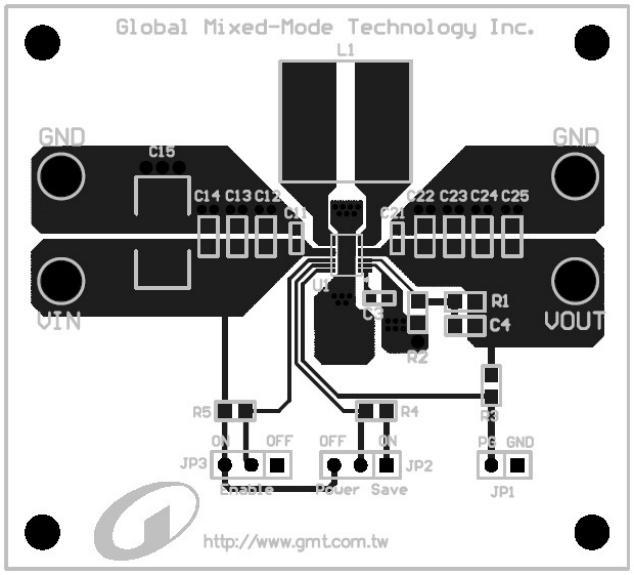
Careful PCB layout is critical to achieve clean and stable operation. It is highly recommended to duplicate the M2224 evaluation kit layout for optimum performance. If deviation is necessary, follow these guidelines for good PCB layout:

- Place the input and output capacitors as close as possible to the input and output pins.
- Keep the main power traces as wide and short a possible.
- Connect the GND and Exposed Pad to a strong ground plane for maximum thermal dissipation and noise protection.
- Switch node experiences high frequency voltage swings and should be kelp in a small area. Keep analog components away from the switch node to prevent stray capacitive noise pick-up.

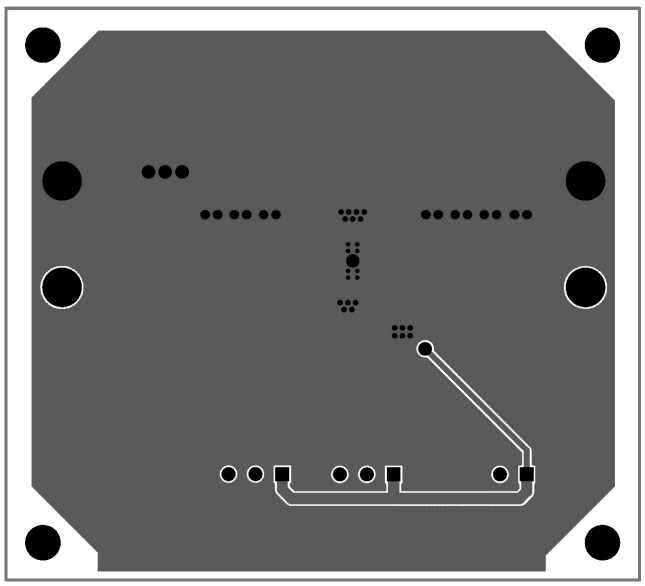


Board Layout

Top Side

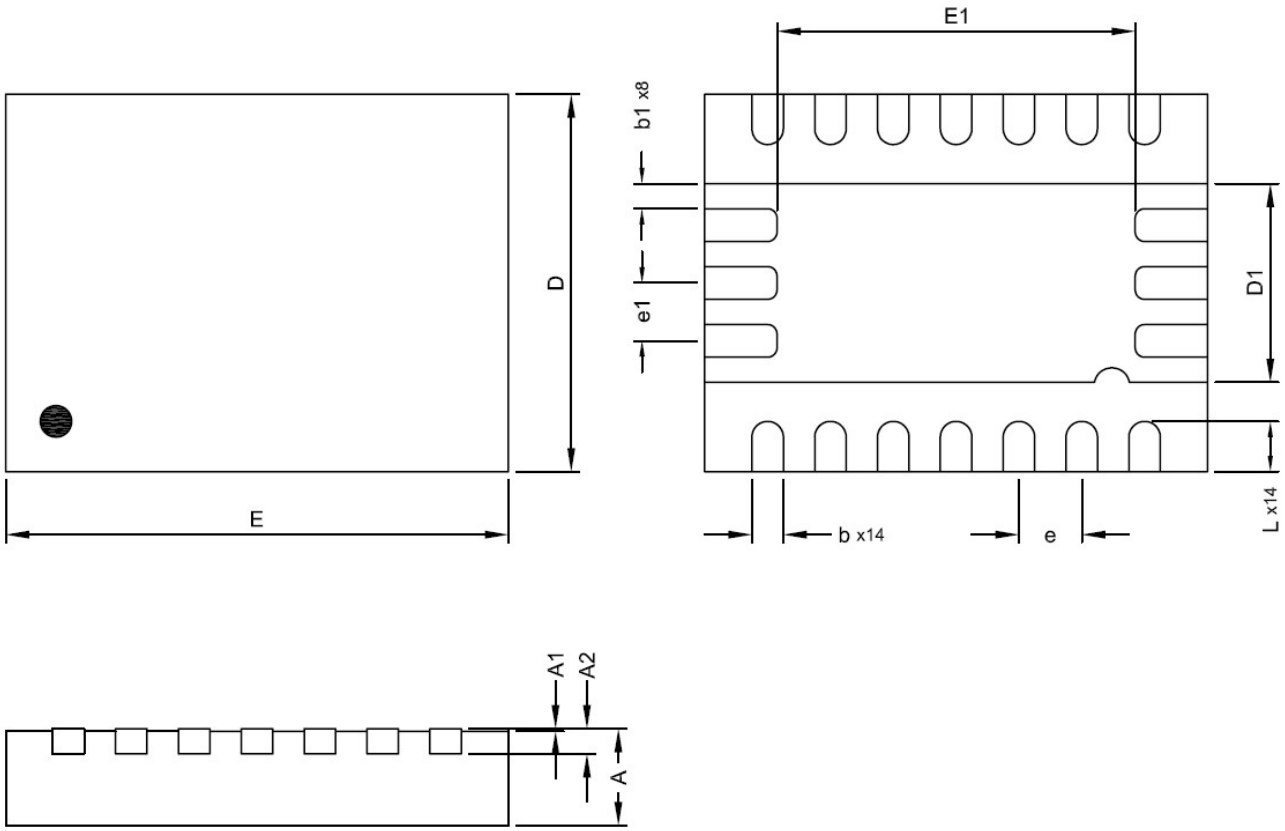


Bottom side



Information	TDFN3X4-14 Board
Board Material	FR4
Size	60.07mm×54.23mm
Board Thickness	1.6mm
Layers	2
Copper Thickness	1 oz.
Thermal Vias	9
Maximum Thermal Vias Size	43mil

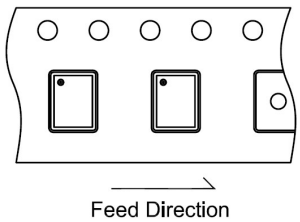
Package Information



TDFN3X4-14 Package

Symbol	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.0276	0.0295	0.0315
A1	0.00	- - -	0.05	0.0000	- - -	0.0020
A2	0.20 REF			0.0079		
D	2.90	3.00	3.10	0.1142	0.1181	0.1220
E	3.90	4.00	4.10	0.1535	0.1575	0.1614
D1	1.53	1.58	1.63	0.0602	0.0622	0.0642
E1	2.80	2.85	2.90	0.1102	01122	0.1142
b	0.20	0.25	0.30	0.0078	0.0098	0.0118
b1	0.20 REF			0.0079 REF		
e	0.50 BSC			0.0197 BSC		
e1	0.46 BSC			0.0181 BSC		
L	0.35	0.40	0.45	0.0138	0.0157	0.0177

Taping Specification



PACKAGE	Q'TY/REEL
TDFN3X4-14	3,000 ea