5V Input 2A 2.5MHz Synchronous Step-Down Converter

DESCRIPTION

The MT3102 is a 2.5MHz, 2A constant on-time (COT) controlled synchronous step-down converter. It can operate with input voltage from 2.5V to 6V and provide output range from 0.6V to input level, thanks to its 100% duty cycle operation. The constant on-time control scheme simplifies loop compensation and offers excellent load transient response. MT3102 consumes extremely low 15µA quiescent current hence achieves superior light load efficiency. The high gain error amplifier in the control loop provides excellent load and line regulation. Proprietary adaptive on-time helps MT3102 to achieve nearly constant switching frequency across load range, as for operation mode:

- MT3102 is COT PFM mode.
- MT3102A is COT Forced PWM mode.

MT3102 has cycle-by-cycle current limit and hiccup mode to protect over-load or short circuit fault conditions.

MT3102 is available in low profile 5 leads SOT23, 6 leads DFN 1.5mm x 1.5mm, DFN 1.5mm x 1mm and SOT23 packages.

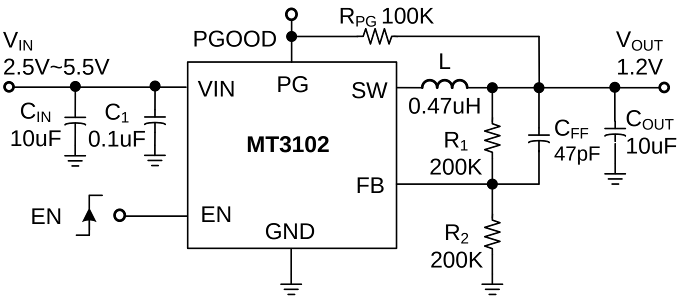
FEATURES

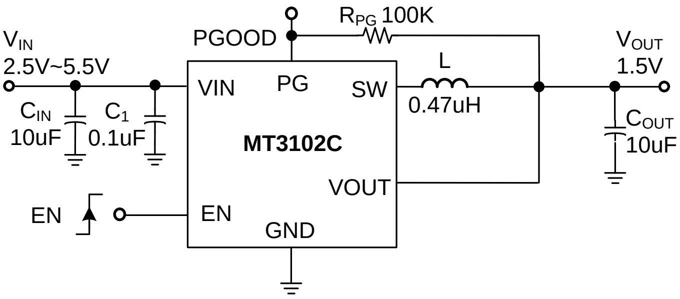
- Wide Input Range from 2.5V to 6V
- Proprietary Fast Transient Constant On Time Architecture Stable with low ESR Ceramic Output Capacitors
- +/- 2%, 0.6V Feedback Voltage/Fixed VOUT
- 2.5MHz Switching Frequency
- 15µA Low Quiescent Current
- 2A Continuous
- 1.21V Accurate Enable Threshold
- Up to 95% Efficiency
- 100% Duty Cycle Operation
- Built-in 110mΩ/90mΩ Power Switches
- Internal 1msec Soft-Start
- Cycle-by-cycle Current Limit Protection
- Over-Load and Short Circuit Hiccup Mode
- Open Drain Power Good Indication Option
- Output Discharge
- Thermal Shutdown Protection
- Available in Small SOT23_5L, SOT23_6L, DFN1.5x1.5_6L and DFN1.5x1_6L Package
- Pb-Free RoHS Compliant

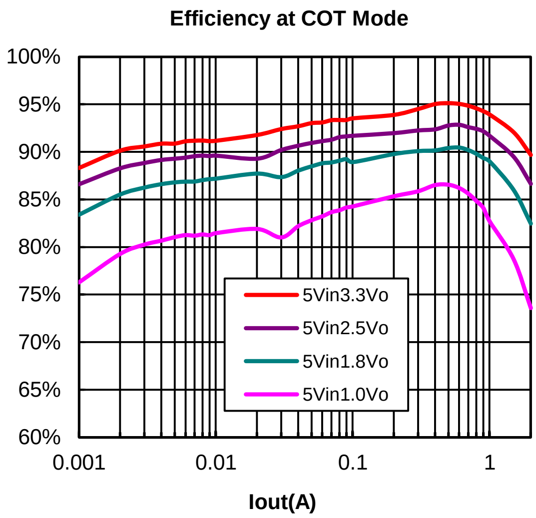
APPLICATIONS

- Solid-State and Hard Disk Drives
- WiFi RF Modules
- DC/DC Micro Modules
- Smart Phone and Tablets

Typical Applications





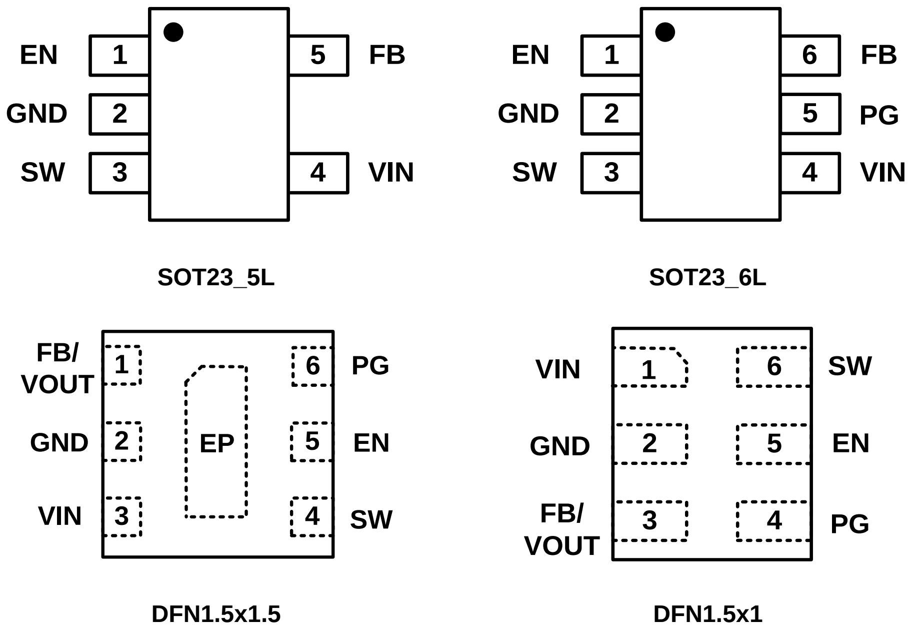


Ordering Information

Part No.	Marking	Temp. Range	Remark	Package	MOQ
MT3102NSBR	3102 YWWxx	-40°C ~+85°C	Adjustable Vout	SOT23_5L	3000/Tape & Reel
MT3102ASBR	3102A YWWxx	-40°C ~+85°C	Adjustable Vout Forced PWM	SOT23_5L	3000/Tape & Reel
MT3102NSCR	3102 YWWxx	-40°C ~+85°C	Adjustable Vout	SOT23_6L	3000/Tape & Reel
MT3102NGAR	3102 YWxx	-40°C ~+85°C	Adjustable Vout	DFN1.5x1.5_6L	3000/Tape & Reel
MT3102T105GAR	102T YWxx	-40°C ~+85°C	Fixed 1.05V	DFN1.5x1.5_6L	3000/Tape & Reel
MT3102C15GAR	102C YWxx	-40°C ~+85°C	Fixed 1.5V	DFN1.5x1.5_6L	3000/Tape & Reel
MT3102D18GAR	102D YWxx	-40°C ~+85°C	Fixed 1.8V	DFN1.5x1.5_6L	3000/Tape & Reel
MT3102V22GAR	102V YWxx	-40°C ~+85°C	Fixed 2.2V	DFN1.5x1.5_6L	3000/Tape & Reel
MT3102NDGR	ENYW	-40°C ~+85°C	Adjustable Vout	DFN1.5x1_6L	3000/Tape & Reel
MT3102ADGR	FNYW	-40°C ~+85°C	Adjustable Vout Forced PWM	DFN1.5x1_6L	3000/Tape & Reel
MT3102T105DGR	ETYW	-40°C ~+85°C	Fixed 1.05V	DFN1.5x1_6L	3000/Tape & Reel
MT3102C15DGR	ECYW	-40°C ~+85°C	Fixed 1.5V	DFN1.5x1_6L	3000/Tape & Reel
MT3102D18DGR	EDYW	-40°C ~+85°C	Fixed 1.8V	DFN1.5x1_6L	3000/Tape & Reel
MT3102V22DGR	EVYW	-40°C ~+85°C	Fixed 2.2V	DFN1.5x1_6L	3000/Tape & Reel

Note: Y: Year, W: Week, x: Manufacture Code

Pin Configuration



Top View

Pin Description

SOT23_5 Pin No.	SOT23_6 Pin No.	DFN1.5x1.5 Pin No	DFN1.5x1 Pin No.	Symbol	Description
1	1	5	5	EN	Regulator Enable Control Input with accurate 1.21V enable threshold which can be used to build precision R-C turn-on delay and input under-voltage lockout. This pin has a pull-down resistor of typically 1MΩ to GND. • Drive EN above 1.21V to turn on the converter • Drive EN below 1.11V to turn off the converter and discharge output
2	2	2, EP	2	GND	Ground
3	3	4	6	SW	Power Switch Node
4	4	3	1	VIN	Input Supply Voltage
-	5	6	4	PG	Power Good Open-drain Output. Connect a 100kΩ pull-up resistor to V_{IN} or V_{OUT}.
5	6	1	3	FB	Voltage Feedback Input. Connect a resistor divider between output and FB to program the output voltage. VFB is regulated to 0.6V.
-	-	1	3	VOUT	Output Voltage Feedback Input for Fixed VOUT Revision

Absolute Maximum Rating (Reference to GND) (Note1)

V_{IN} ………………………………………. -0.3V to +6.5V
V_{SW} ………………………………………. -0.3V to V_{IN} +0.3V
Dynamic V_{SW} in 10ns Duration ………… -3V to V_{IN} +3V
The other Pins …………………………….. -0.3V to +6.5V
Junction Temperature Range …….. -40°C to +150°C
Storage Temperature Range ……... -65°C to +150°C
ESD ……………………………………………. Class 2
Lead Temperature(Soldering 10s) …………. 260°C

Recommend Operating Conditions (Note2)

Input Voltage (V_{BAT}) ……………………… +2.5V to +6V
Output Voltage (V_{OUT}) ……………………… +0.6V to V_{IN}
Operating Temperature Range …….. -40°C to +85°C

Thermal information (Note3, 4)

Maximum Power Dissipation(T_A=25°C)
SOT23(5L/6L) ………………………………………. 0.48W
DFN1.5x1.5_6L ………………………………………. 1W

DFN1.5x1_6L ………………………………………. 1.14W

Thermal Resistance(θ_{JA}) SOT23(5L/6L) ….. 210°C/W
Thermal Resistance(θ_{JC}) SOT23(5L/6L) …. 100°C/W
Thermal Resistance(θ_{JA}) DFN1.5x1.5 ……. 135°C/W
Thermal Resistance(θ_{JC}) DFN1.5x1.5 ……… 50°C/W
Thermal Resistance(θJA) DFN1.5x1 ……… 110°C/W
Thermal Resistance(θJC) DFN1.5x1 ………… 55°C/W

Note (1): Stress exceeding those listed "Absolute Maximum Ratings" may damage the device.
Note (2): The device is not guaranteed to function outside of the recommended operating conditions.
Note (3): Measured on JESD51-7, 4-Layer PCB.
Note (4): The maximum allowable power dissipation is a function of the maximum junction temperature T_{J_MAX}, the junction to ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by $P_{D\_MAX}= (T_{J\_MAX}-T_A)/\theta_{JA}$. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.

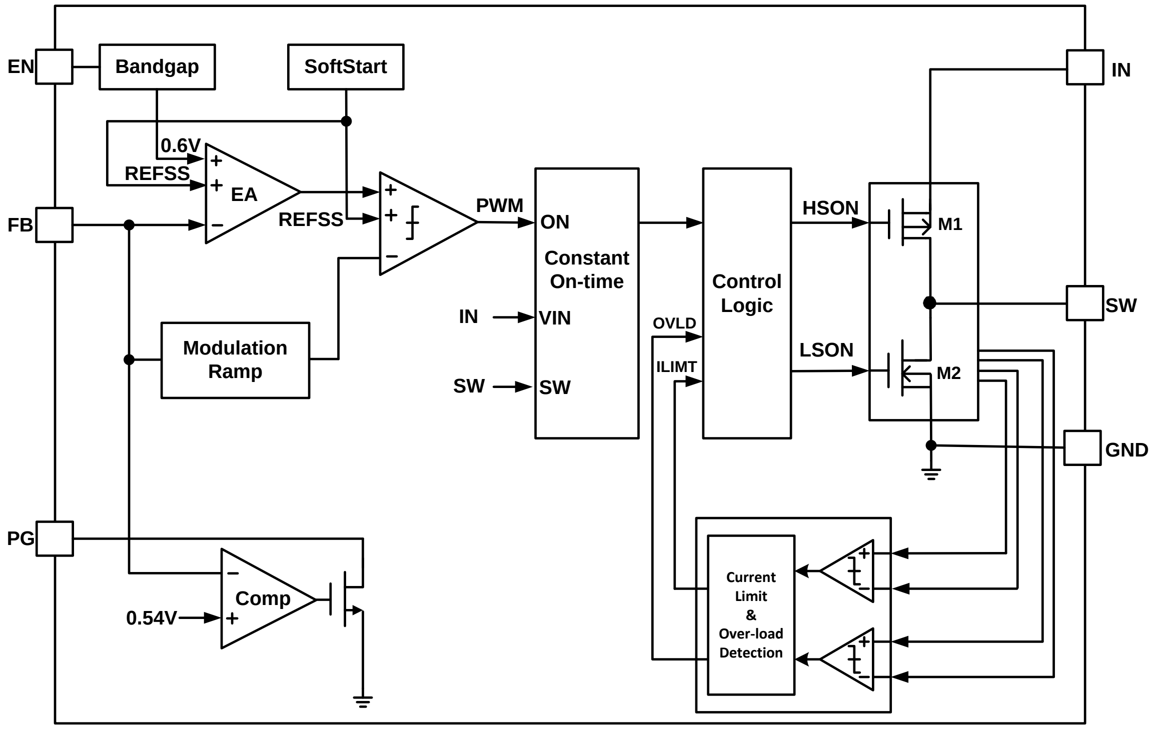
Electrical Characteristics

T_A = 25°C, V_{IN}=5V, unless otherwise noted. Typical values are at V_{IN} = V_{EN} = 5V and V_{OUT} = 1.8V.

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input Voltage Range V_{IN}		2.5		6.0	V
Shutdown Current	V_{EN} = 0V, V_{IN} = 5.5V		0.1	1	μA
Input Under Voltage Lockout Threshold	V_{IN} Increasing	2.3	2.4	2.5	V
Input Under Voltage Lockout Hysteresis			280		mV
Quiescent Current I_Q	V_{FB} = 0.63V		15	20	μA
Feedback Voltage V_{FB}		588	600	612	mV
Feedback Current I_{FB}		-50	1	+50	nA
HS Switch Peak Current Limit		2.8	3.3	3.8	A
HS Main Switch On Resistance	V_{IN}=5V		110		mΩ
LS Synchronous Switch On Resistance	V_{IN}=5V		90		mΩ
HS Leakage Current	V_{IN} = 5.5V, V_{EN} = V_{SW} = 0V		0.1	2	μA
LS Leakage Current	V_{IN} = V_{SW} = 5.5V, V_{EN} = 0V		0.1	2	μA

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
PWM Switching Frequency	I_{IOUT} = 1A		2.5		MHz
PGOOD Output Low Voltage	V_{FB} =0.5V, sink 1mA		0.2	0.3	V
PGOOD Output Leakage Current	V_{FB} = 0.63V , V_{PGOOD} = V_{IN} = 5.5V		0.01	0.2	µA
PGOOD Under Voltage Rise Threshold	V_{FB} ramp up from under voltage	-12	-10	-8	%
PGOOD Under Voltage Fall Threshold	V_{FB} ramp down from regulation		-15		%
PGOOD Delay	PGOOD going High to Low		30		µsec
EN On Threshold	V_{EN} ramp up	1.18	1.21	1.24	V
EN Off Threshold	V_{EN} ramp down		1.11		
EN Internal Pull Down Resistor		700	1000	1300	kΩ
Thermal Shutdown			160		℃
Thermal Shutdown Hysteresis			30		℃

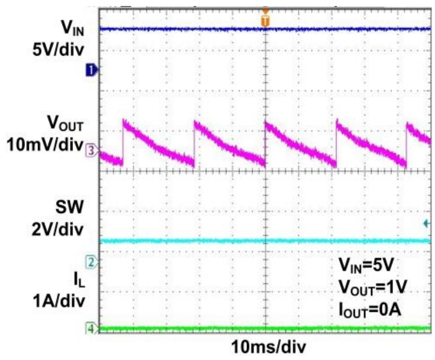
Functional Block Diagram



TYPICAL PERFORMANCE CHARACTERISTICS

C_{IN}=10uF, C_{OUT}=10uF, L=0.47uH, T_A=+25℃

Steady State Test



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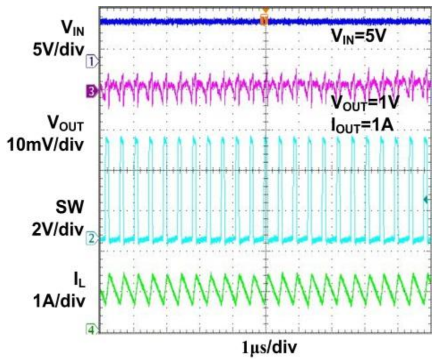

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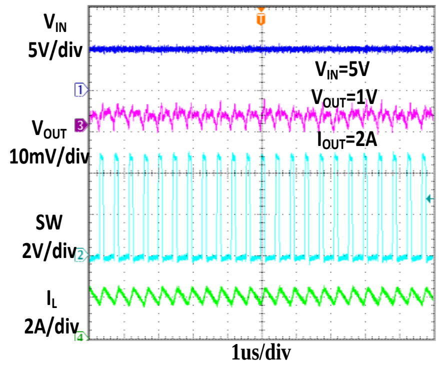

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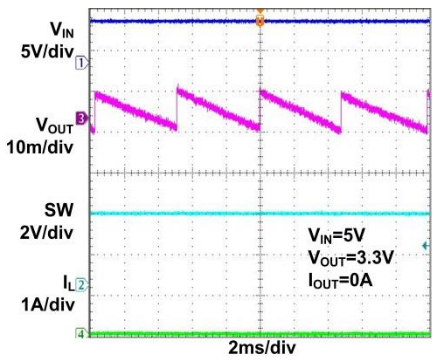

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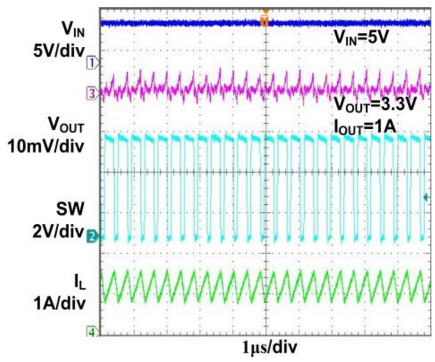

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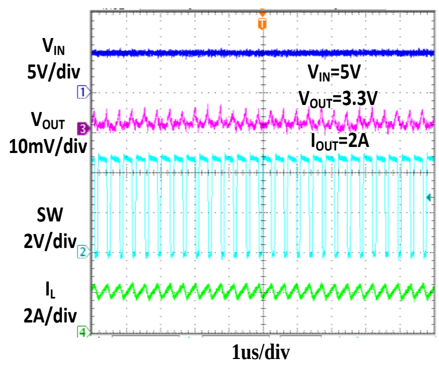

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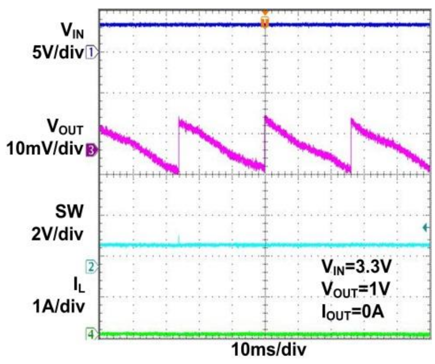

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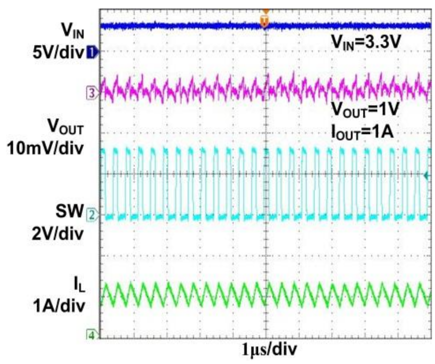

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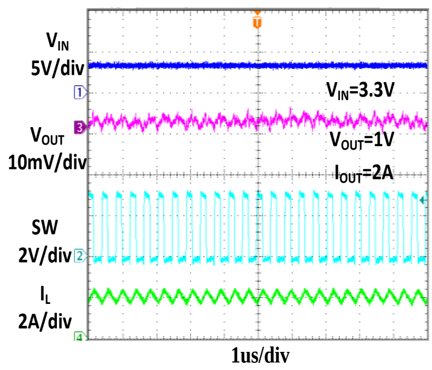

TYPICAL PERFORMANCE CHARACTERISTICS

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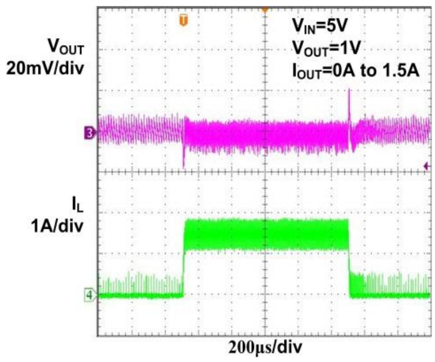
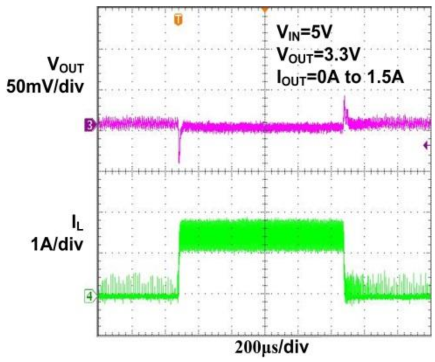
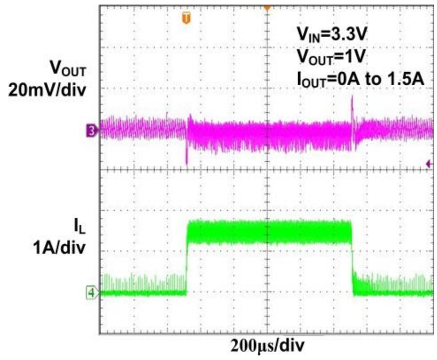
Load Transient Response



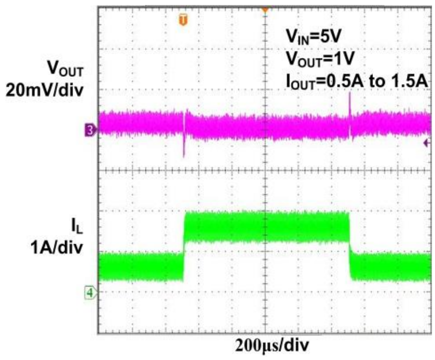
Load Transient Response



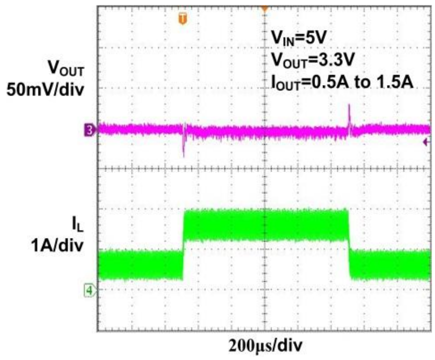
Load Transient Response



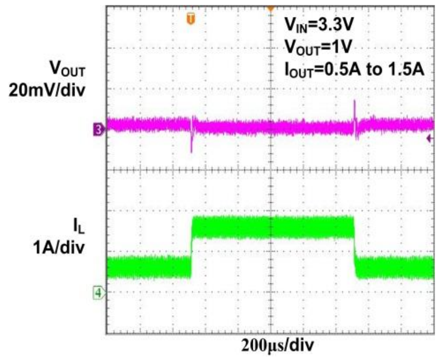
Load Transient Response



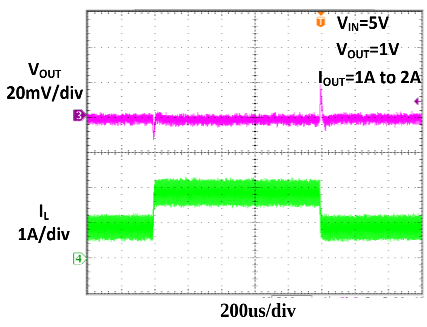
Load Transient Response



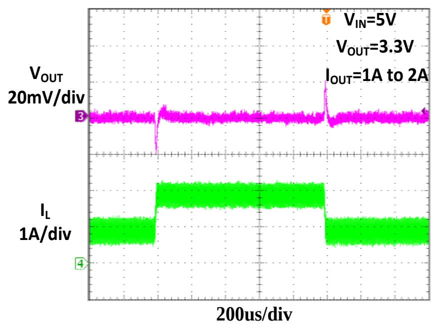
Load Transient Response



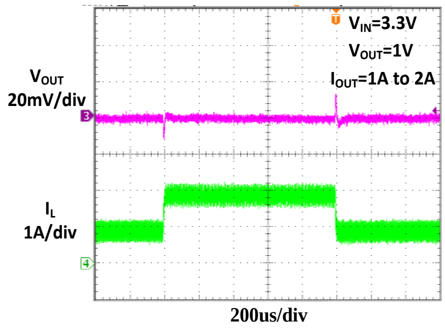
Load Transient Response 1A~2A



Load Transient Response 1A~2A



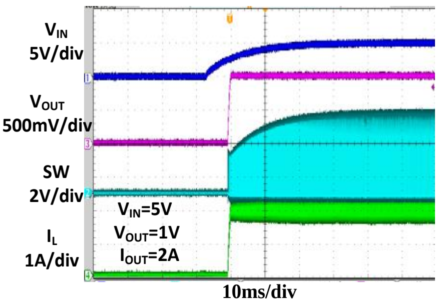
Load Transient Response 1A~2A



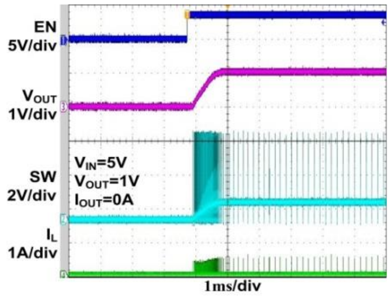
TYPICAL PERFORMANCE CHARACTERISTICS

C_{IN}=10uF, C_{OUT}=10uF, L=0.47uH, T_A=+25℃

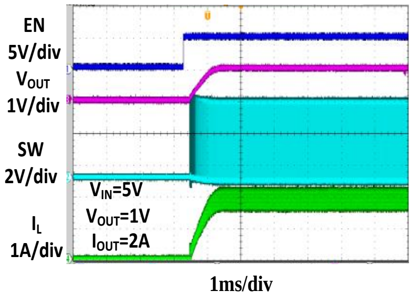
Vin Power On



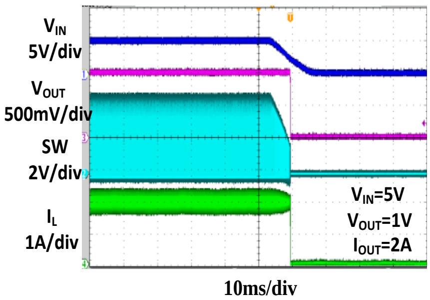
EN On



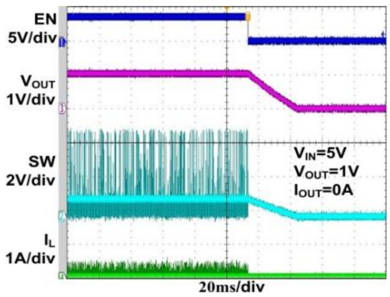
EN On



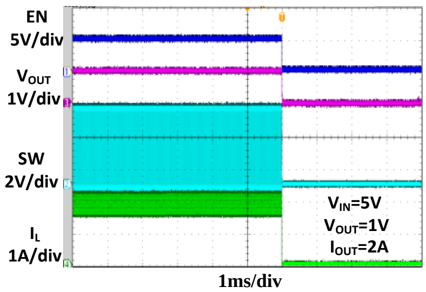
Vin Power Off



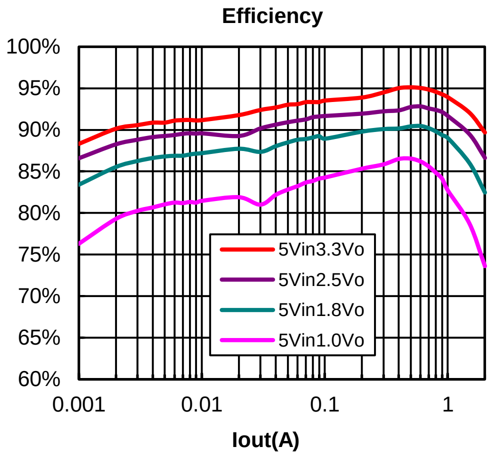
EN Off



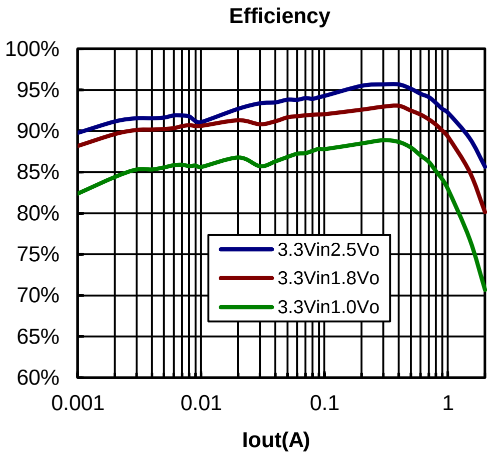
EN Off



Efficiency at 5Vin



Efficiency at 3.3Vin



Theory of Operation

MT3102 is a constant on-time control synchronous step-down converter that offers excellent transient response over a wide range of input voltage. It achieves superior light-load efficiency with extremely low quiescent current.

Constant On-time Control

Constant on-time control step-down converters turn on HS immediately when FB droops below reference. The HS is turned on for a pre-determined period (on-time) of time to ramp up the inductor current, and then the LS will be turned on to ramp down the inductor current. The cycle repeats itself if FB droops below reference again. MT3102 uses proprietary technique to take into account the load current impact and adjusts the on-time accordingly to achieve a constant switching frequency over entire load current range.

For MT3102, the on-time is approximately:

$$T_{ON} = \frac{V_{OUT}}{V_{IN}} \cdot 0.4\mu$$

Due to its immediate response on FB voltage droop and simplified loop compensation, constant on-time offers a superior transient response compare to traditional fixed frequency PWM control step-down converters.

Light Load Operation

In light load condition where the converter operates in discontinuous mode, MT3102 cuts down its quiescent current to as low as 15uA and achieves excellent light load efficiency.

Enable

When input voltage is above the under voltage lock-out threshold, MT3102 can be enabled by pulling the EN pin to above 1.21V. MT3102 is disabled if the EN pin is pulled below 1.1V. The enable/disable threshold for EN pin is accurately designed to be 1.21V and 1.11V respectively, so one can also use external resistor divider to program the desired input under-voltage lockout level.

Soft Start

MT3102 has built-in soft start of 1ms. During the soft start period, output voltage is ramped up linearly to the regulation voltage, independent of the load current level and output capacitor value.

Current Limit and Hiccup Mode

MT3102 has cycle-by-cycle HS current limit protection to prevent inductor current from running away. Once HS current limit is triggered, MT3102 will turn on LS and wait for the inductor to drop down to a pre-determined level before the HS can be turned on again. If this current limit condition is repeated for a sustained long period of time, MT3102 will consider it over-load or short circuit. Either way, MT3102 will enter hiccup mode, where it stop switching for a pre-determined period of time before automatically re-try to start up again. It always starts up with soft-start to limit inrush current and avoid output overshoot.

Power Good Indication

MT3102 has open drain Power GOOD indicator PGOOD pin. When PGOOD is connected with external pull up resistor, it will be pulled up if output voltage is higher than 90% of regulation, otherwise PGOOD is pulled down by the internal open drain NMOS.

Application Information

Setting the Output Voltage

External feedback resistors are used to set the output voltage. Refer to typical application circuit on page1, the top feedback resistor R1 has some impact on the loop stability, so its recommended range is between 100kΩ-300kΩ. For any chosen R1, the bottom feedback resistor R2 can be calculated as:

$$R_2 = \frac{R_1}{\frac{V_{OUT}}{0.6} - 1}$$

Inductor Selection

The recommended inductor value for MT3102 is between 0.33uH to 1uH. Usually the inductor value is chosen to satisfy a desired ripple current:

$$L = \frac{V_{OUT} \cdot (V_{IN} - V_{OUT})}{V_{IN} \cdot f_{SW} \cdot \Delta I}$$

where ΔI is the inductor ripple current.

With the chosen ΔI, the peak inductor current will be:

$$I_{PK} = I_{LOAD} + \frac{1}{2} \cdot \Delta I$$

Input Bypass Capacitor Selection

The input current to the step-down converter is discontinuous with very sharp edges, therefore an input bypass capacitor is required. For best performance, it's recommended to use low ESR ceramic capacitors and place them as close to the input pin as possible. For lowest temperature variations, use X5R or X7R dielectric ceramic capacitors.

The RMS current of the input capacitor is approximately:

$$I_{CIN\_RMS} = I_{OUT}\sqrt{D(1 - D)}$$

From the equation, it can be seen that the highest RMS current occurs when D is 0.5:

$$I_{CIN\_RMS} = \frac{1}{2} I_{OUT}$$

Choose the capacitor with RMS current rating higher than 1/2 I_{OUT}

The power dissipation on the input capacitor can be estimated with the RMS current and the ESR resistor.

Electrolytic or tantalum capacitors can also be used, but due to their significantly higher ESR, a small size ceramic capacitor should be placed as close to the IC as possible.

The voltage ripple on the input capacitor, neglecting the ESR impact, can be calculated as:

$$\Delta V_{CIN} = \frac{I_{LOAD}}{f_{SW} \cdot C_{IN}} \cdot \frac{V_{OUT}}{V_{IN}} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Output Capacitor Selection

An output capacitor is required to obtain a stable output voltage. To minimize the output voltage ripple, ceramic capacitors should be used, and the ripple voltage can be estimated as:

$$\Delta V_{OUT} = \frac{1}{8} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \cdot \frac{V_{OUT}}{L} \cdot \frac{1}{(f_{SW})^2 \cdot C_{OUT}}$$

If electrolytic or tantalum capacitors are used, the ESR will dominate the output voltage ripple:

$$\Delta V_{OUT} = \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \cdot \frac{V_{OUT}}{f_{SW} \cdot L} \cdot R_{ESR}$$

PCB Layout Recommendation

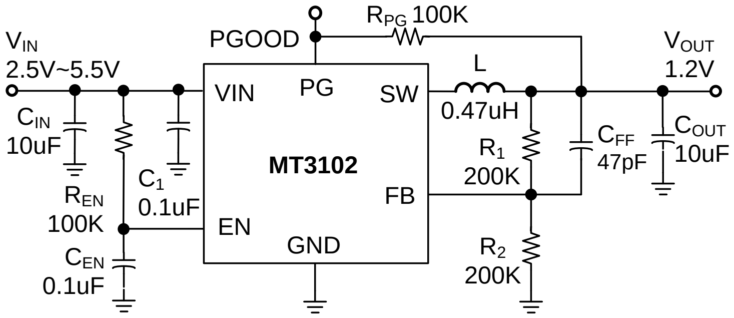
The physical design of the PCB is the final stage in the design of power converter. If designed improperly, the PCB could radiate excessive EMI and contribute instability to the power converter. Therefore, following the PCB layout guidelines below can ensure better performance of MT3102.

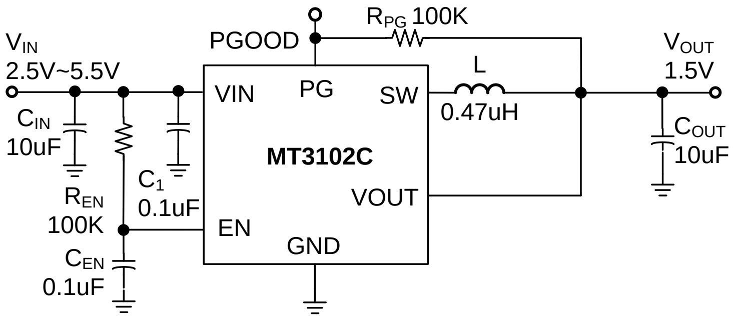
(1). The loop (Vin-SW-L-Cout-GND) indicates a high current path. The traces within the loop should be kept as wide and short as possible to reduce parasitic inductance and high-frequency loop area. It is also good for efficiency improvement.

(2). Input capacitor as close as possible to the IC Pins (Vin and GND) and the input loop area should be as small as possible to reduce parasitic inductance, input voltage spike and noise emission.

(3). Feedback components (R_1, R_2 and C_{FF}) should be routed as far away from the inductor and the SW Pin as possible to minimize noise and EMI issue.

MT3102 Application Schematic



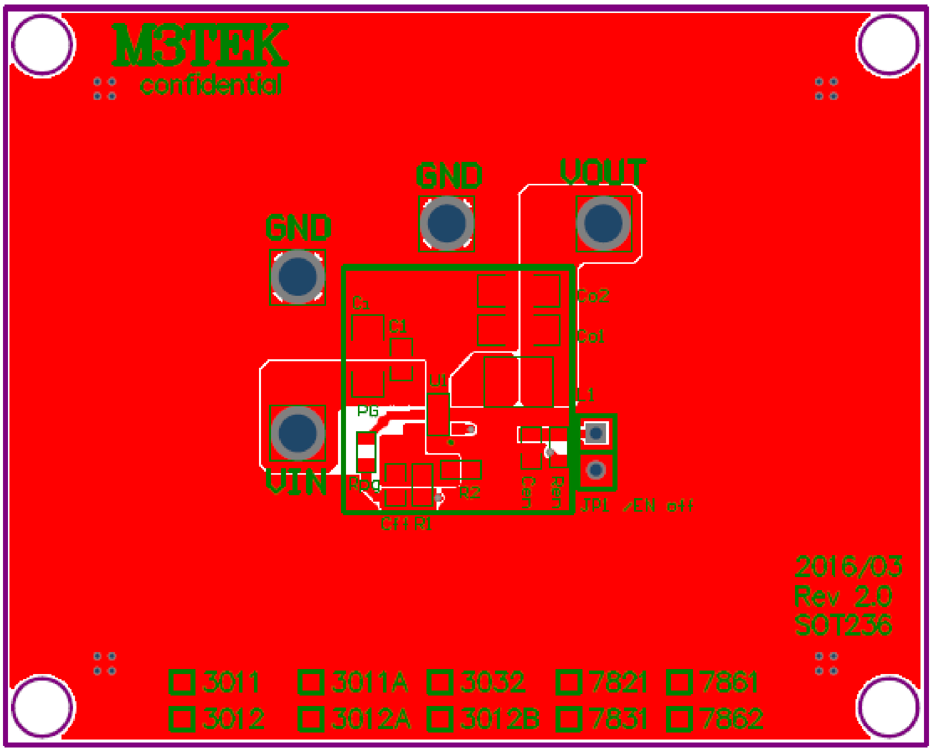


EVB BOM List

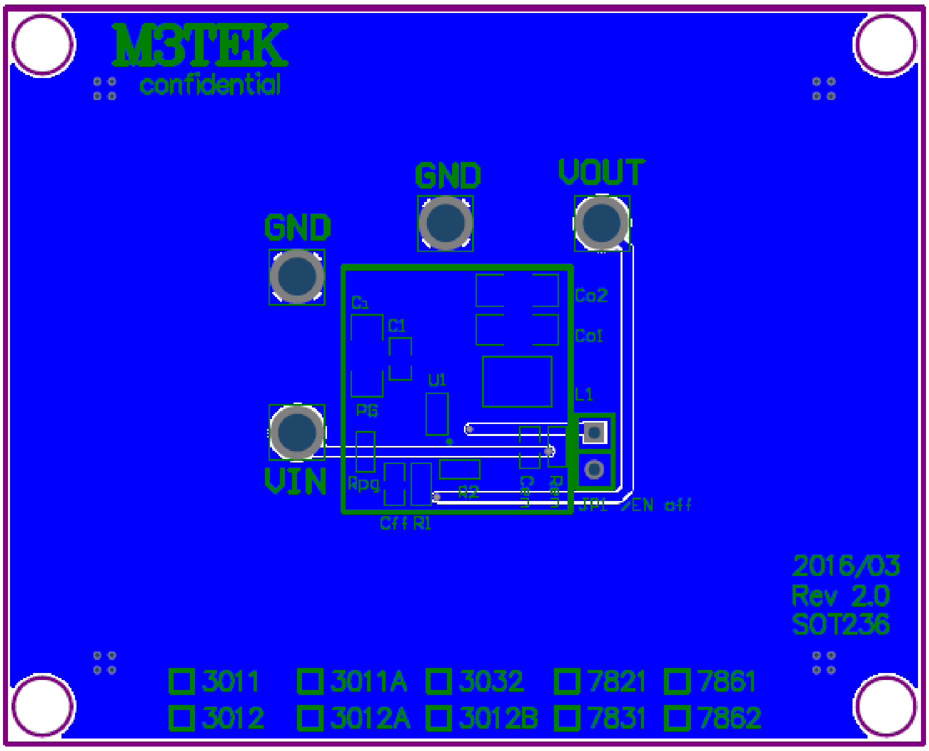
Qty	Ref	Value		Description	Package
1	C_{IN}	10µF		Ceramic Capacitor, 10V, X5R	0805
1	C_{OUT}	10µF		Ceramic Capacitor, 10V, X5R	0805
2	C1, C_{EN}	0.1µF		Ceramic Capacitor, 10V, X5R	0603
1	C_{FF}	47pF		Ceramic Capacitor, 10V, X5R	0603
1	L	0.47uH 0.33uH~1µH		Inductor, HEI201208A-R47M-Q8, 40mΩ, 3.6A Inductor, MHCI04020-R47M, 14mΩ, 9.5A	0805 SMD
1	R1	Vout=3.3V	200KΩ	Resistor, ±1%	0603
		Vout=2.5V	240KΩ		
		Vout=1.8V	200KΩ		
		Vout=1.2V	200KΩ		
		Vout=1.0V	100KΩ		
1	R2	Vout=3.3V	43KΩ	Resistor, ±1%	0603
		Vout=2.5V	75KΩ		
		Vout=1.8V	100KΩ		
		Vout=1.2V	200KΩ		
		Vout=1.0V	150KΩ		
2	R_{PG}, R_{EN}	100KΩ		Resistor, ±1%	0603
1	Power IC	MT3102		Step-Down DC/DC Converter	-

EVB Layout

SOT236

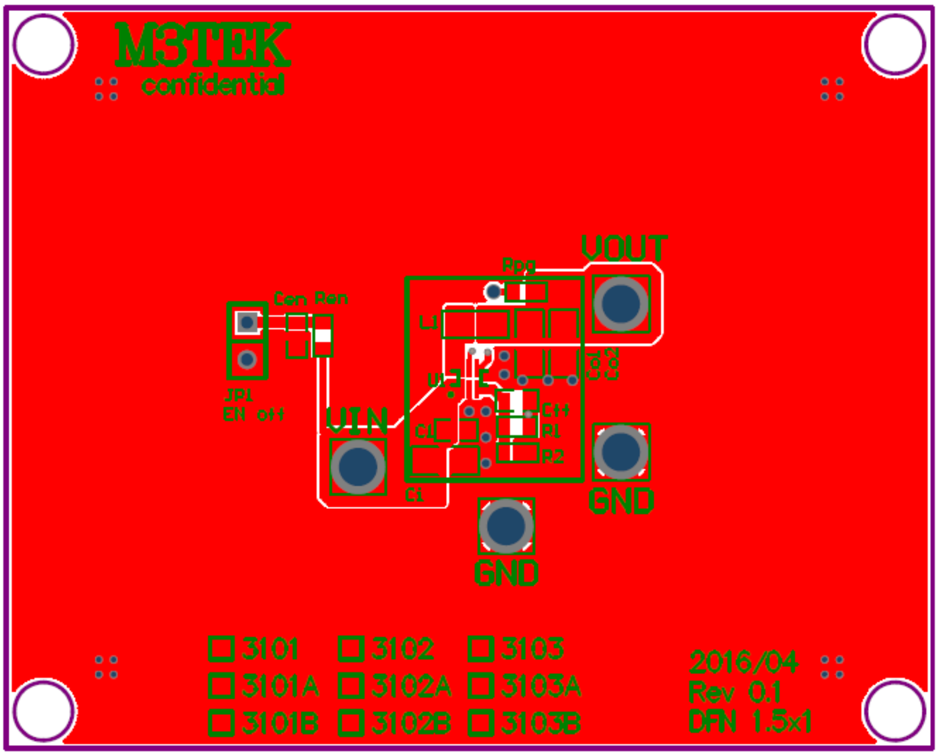


Top Layer

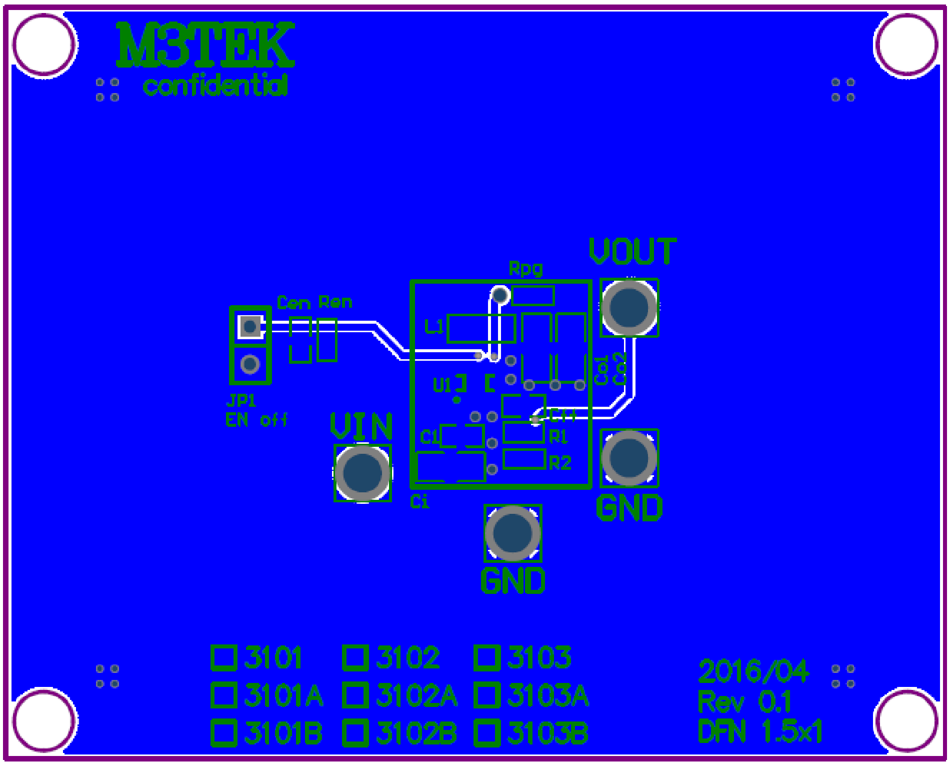


Bottom Layer

DFN1.5x1

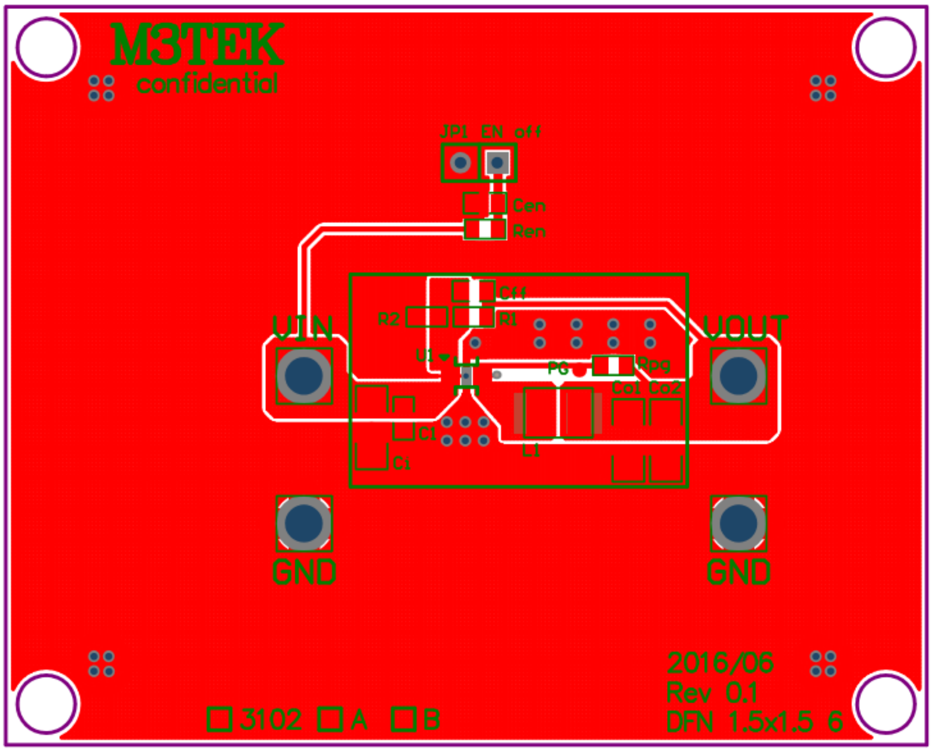


Top Layer

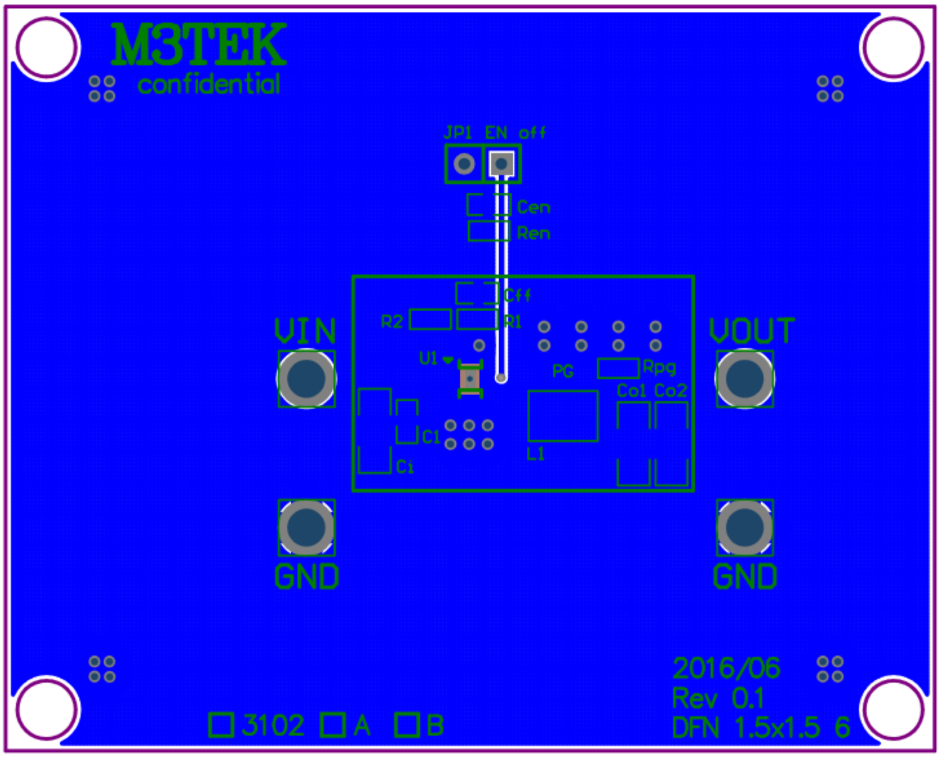


Bottom Layer

DFN1.5x1.5



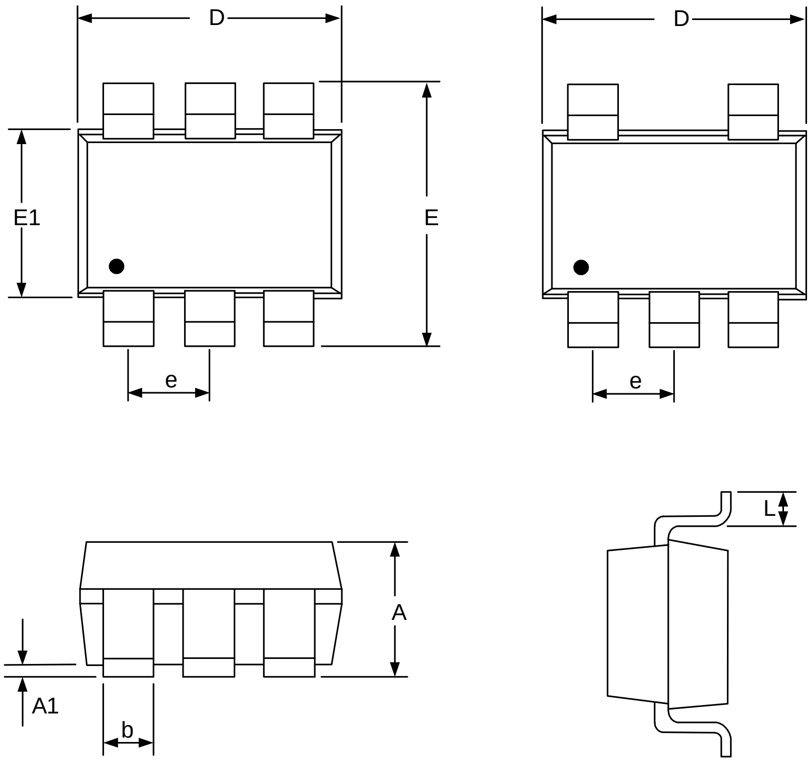
Top Layer



Bottom Layer

Package Information

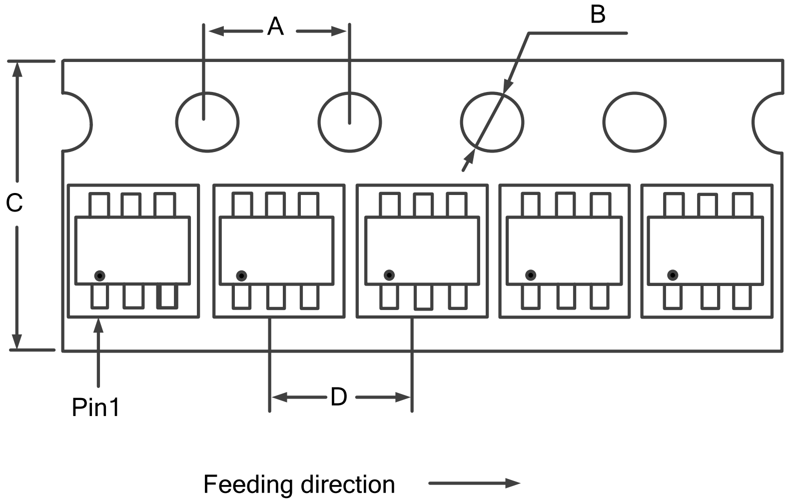
SOT23_5L and SOT23_6L Outline Dimensions
Unit: inches/mm



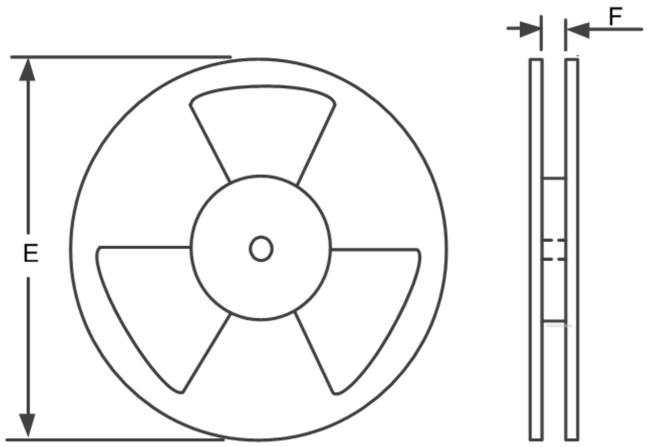
SYMBOLS	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.89	1.45	0.035	0.057
A1	0.00	0.15	0.000	0.006
b	0.30	0.50	0.012	0.020
D	2.70	3.10	0.106	0.122
E1	1.40	1.80	0.055	0.071
e	0.95 BSC		0.037 BSC	
E	2.60	3.00	0.102	0.118
L	0.30	0.60	0.012	0.024

Tape & Reel Carrier Dimensions

1. Orientation / Carrier Tape Information :



2. Rokreel Information :



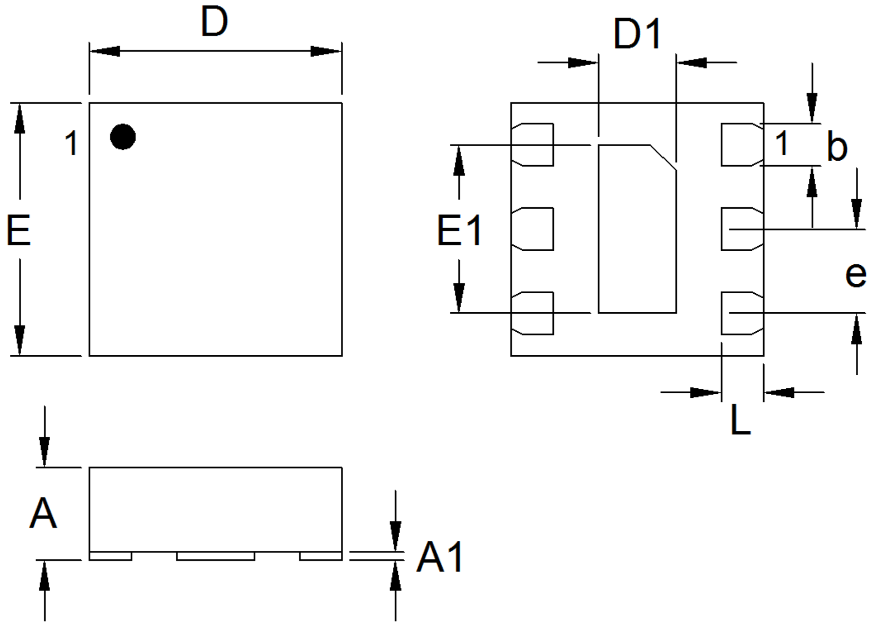
3. Dimension Details :

PKG Type	A	B	C	D	E	F	Q'ty/Reel
SOT23	4.0 mm	1.5 mm	8.0 mm	4.0 mm	7 inches	9.0 mm	3,000

Package Information

DFN1.5x1.5_6L Outline Dimensions

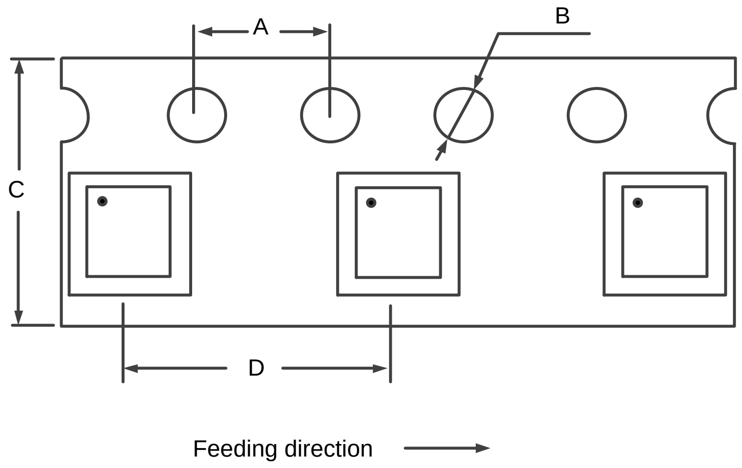
Unit: inches/mm



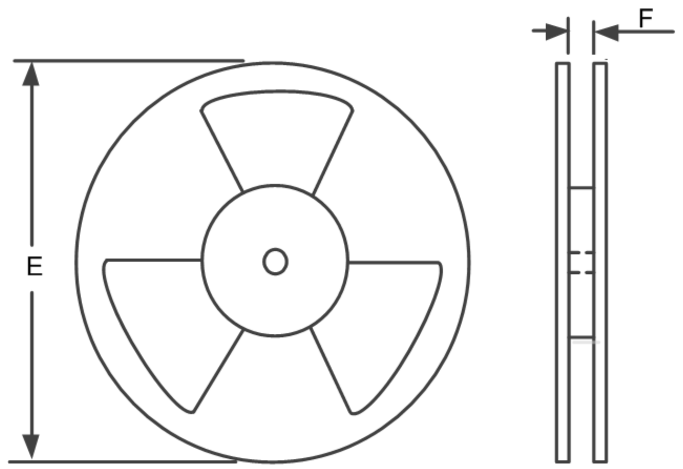
SYMBOLS	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.50	0.60	0.020	0.024
A1	0.00	0.05	0.000	0.002
b	0.20	0.30	0.008	0.012
D	1.40	1.60	0.055	0.063
D1	0.36	0.56	0.014	0.022
E	1.40	1.60	0.055	0.063
E1	0.90	1.10	0.035	0.043
e	0.50 BSC		0.020 BSC	
L	0.174	0.326	0.007	0.013

Tape & Reel Carrier Dimensions

1. Orientation / Carrier Tape Information :



2. **Rokreel Information :**

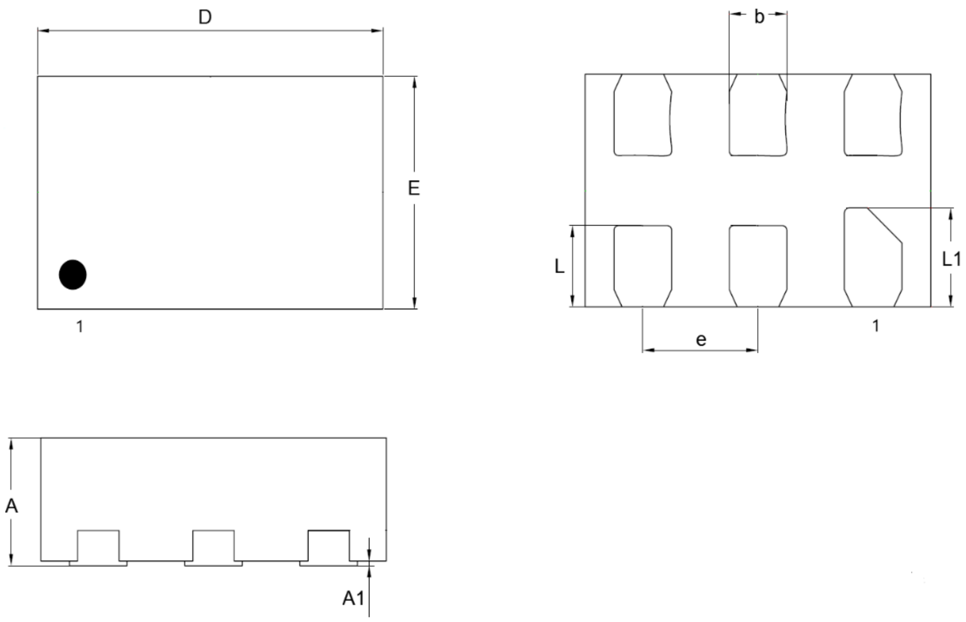


3. **Dimension Details :**

PKG Type	A	B	C	D	E	F	Q'ty/Reel
DFN1.5x1.5	4.0 mm	1.5 mm	8.0 mm	4.0 mm	7 inches	9.0 mm	3,000

Package Information

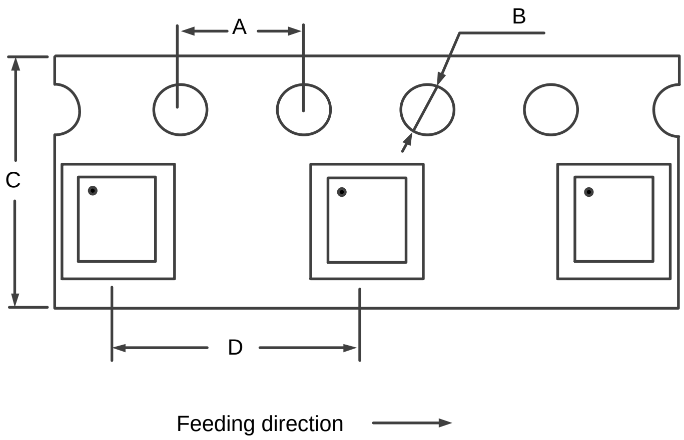
DFN1.5x1_6L Outline Dimensions
Unit: inches/mm



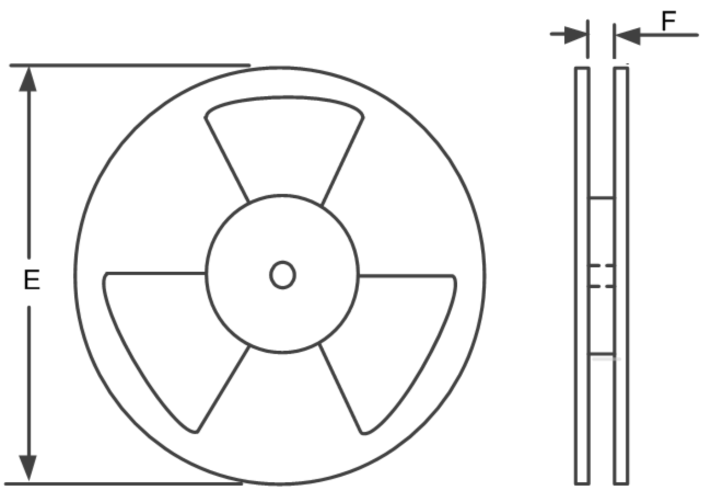
SYMBOLS	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.50	0.60	0.020	0.024
A1	0.00	0.05	0.000	0.002
b	0.20	0.30	0.008	0.012
E	0.90	1.10	0.035	0.043
D	1.40	1.60	0.055	0.063
e	0.50 BSC		0.020 BSC	
L	0.274	0.426	0.011	0.017
L1	0.324	0.476	0.013	0.019

Tape & Reel Carrier Dimensions

1. Orientation / Carrier Tape Information :



2. Rokreel Information :



3. Dimension Details :

PKG Type	A	B	C	D	E	F	Q'ty/Reel
DFN1.5x1	4.0 mm	1.5 mm	8.0 mm	4.0 mm	7 inches	9.0 mm	3,000

Reflow Profile

Classification Of IR Reflow Profile

Reflow Profile	Green Assembly
Average Ramp-Up Rate (Ts_{min} to Tp)	1~2℃/second, 3℃/second max.
Preheat & Soak -Temperature Min(Ts_{min}) -Temperature Max(Ts_{max}) -Time(ts_{min} to ts ts_{max})	 150℃ 200℃ 60~120 seconds
Time maintained above: -Temperature(T_L) -Time(t_L)	 217℃ 60~150 seconds
Peak Temperature(Tp)	See Classification Temp in table 1
Time within 5℃ of actual Peak Temperature(tp)	30 seconds max.
Ramp-Down Rate	6℃/second max.
Time 25℃ to Peak Temperature	8 minutes max.

* Tolerance for peak profile Temperature (T_p) is defined as a supplier minimum and a user maximum.
** Tolerance for time at peak profile temperature (t_p) is defined as a supplier minimum and a user maximum.

Table 1. Pb-free Process – Classification Temperatures (Tc)

Package Thickness	Volume mm^3 <350	Volume mm^3 350-2000	Volume mm^3 >2000
<1.6 mm	260 ℃	260 ℃	260 ℃
1.6 mm – 2.5 mm	260 ℃	250 ℃	245 ℃
2.5 mm	250 ℃	245 ℃	245 ℃

Note: For all temperature information, please refer to topside of the package, measured on the package body surface.