High Efficiency DC/DC Power Module

MPN24AD03-UP-T

FEATURES:

- High Density Power Module
- 3A Output Current
- Input Voltage Range from 4.75V to 26.5V
- Output Voltage Range from 3V to 21V
- 98% Peak Efficiency
- 98% Duty-Cycle Operation
- Output Line-drop Compensation
- Enable / PGOOD Function
- Internal Soft Start
- Protections (OCP, OTP, OVP, UVP, Non-latching)
- DFN Package (7.4 X 8.6 X 6.0mm max)
- Pb-free Available (RoHS compliant)
- MSL 3, 245°C Reflow

GENERAL DESCRIPTION:

The MPN24AD03-UP-T is a high frequency, high power density and complete DC/DC power module. The PWM controller, power MOSFETs and most of support components are integrated into one hybrid package.

The module has automatic operation with PWM mode and power saving mode according to loading. MPN24AD03-UP-T is with single-stage buck conversion allows these devices to directly step down high-voltage input for the highest possible efficiency.

MPN24AD03-UP-T is with programmable output voltage by FB pins and supports USB Power Delivery (PD) requirement

APPLICATIONS:

- Power Supply for Linear Charge
- USB Power Supply

TYPICAL APPLICATION CIRCUIT & PACKAGE SIZE:

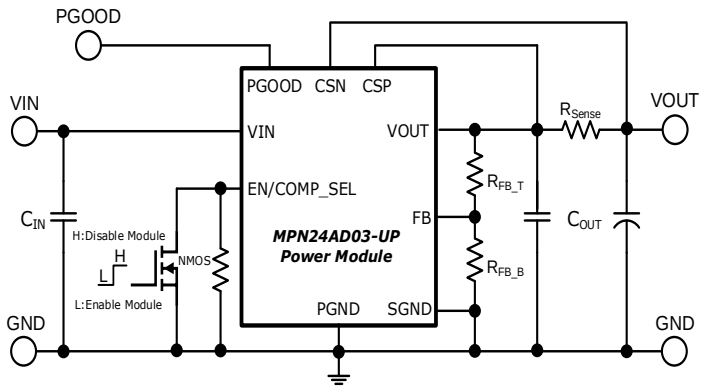


FIG.1 Typical Application Circuit

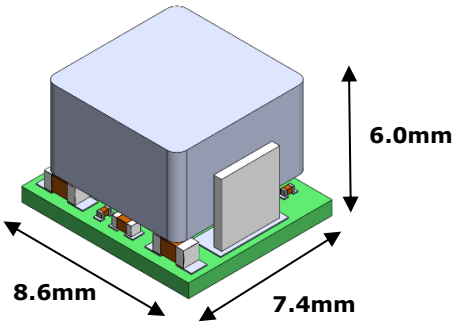


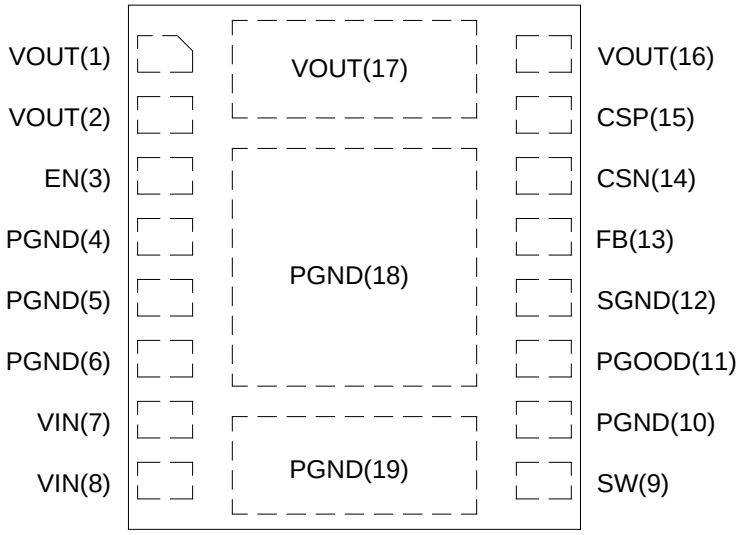
FIG.2 High Density Power Module

ORDER INFORMATION:

Part Number	Ambient Temp. Range (°C)	Package (Pb-Free)	MSL	Note
MPN24AD03-UP-T	-40 ~ +85	DFN	Level 3	-

Order Code	Packing	Quantity
MPN24AD03-UP-T	Tape and Reel	500

PIN CONFIGURATION:



Top View

Symbol	Pin No.	Description
VOUT	1, 2, 16	**Power output pin.** Connect to output for the load.
EN/COMP_SEL	3	**Enable control and adjustable cable compensation pin.** Connect a resistor between EN/COMP_SEL and GND pins to select cable compensation for prevent output voltage drop in the output cable. Pull the EN/COMP_SEL pin < 14kΩ to GND disables the module, the pin floating to enable the module.
PGND	4, 5, 6, 10	**Power ground pin.**
PGOOD	11	**Power OK indication.** This pin is set high impedance after VFB soft start reaches 90% threshold and no fault occurs.
SGND	12	**Analog ground pin.**
VIN	7, 8	**Power input pin.**
SW	9	**Switching node pin.**
FB	13	**Feedback input.** Connect an external resistor divider to set the output voltage.
CSN	14	**The current sense input (-) pin**
CSP	15	**The current sense input (+) pin**

ELECTRICAL SPECIFICATIONS:

CAUTION: Do not operate at or near absolute maximum rating listed for extended periods of time. This stress may adversely impact product reliability and result in failures not covered by warranty.

Parameter	Description	Min.	Typ.	Max.	Unit
■ Absolute Maximum Ratings					
VIN to PGND		-0.3	-	+30	V
CSN,CSP to GND		-0.3	-	+24	V
PGOOD to GND		-0.3	-	+6.0	V
EN/COMP_SEL, to SGND		-0.3	-	+6.0	V
FB to SGND		-0.3	-	+6.0	V
Tc	Choke temperature	-	-	+110	°C
Tj	Operating temperature	-40	-	+125	°C
Tstg	Storage temperature	-40	-	+125	°C
ESD	Human Body Model (HBM)	-	-	2k	V
	Charge Device Model (CDM)	-	-	500	V
■ Recommendation Operating Ratings					
VIN	Input Supply Voltage	+4.75	-	+26.5	V
VOUT	Output Supply Voltage	3	-	+21	V
■ Thermal Information					
Rth(ja)	Thermal resistance from junction to ambient.(Note 2)	-	42.7	-	°C/W

NOTES:
1. The test board size is 30mm×30mm×1.6mm with 4 layers 2oz, on 0 LFM condition.
   The test condition is complied with JEDEC EIJ/JESD 51 Standards.

ELECTRICAL SPECIFICATIONS: (Cont.)

Conditions: T_A = 25 ºC, unless otherwise specified. Test Board Information: 30mm×30mm×1.6mm, 4 layers 2Oz .
The output ripple and transient response measurement is short loop probing and 20MHz bandwidth limited.

Vin = 20.0V, Vout = 5.0V, unless otherwise specified.
Cin = 10uF/50V/1210X 2, Cout = 22uF/25V/1210+56uF/25V (ESR:50mΩ) + 0.1uF/50V/0603

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
■ Input Characteristics						
I_{IN}	Input supply bias current	Iout = 0A Vin = 20V, Vout = 5.0V	-	0.3	-	mA
I_S	Input supply current	Iout = 3A Vin =20V, Vout = 5.0V	-	0.82	-	A
■ Output Characteristics						
$I_{OUT(DC)}$	Output continuous current range	R_{SENSE} = 10mΩ	0	-	3.0	A
$V_{OUT(AC)}$	Output ripple voltage	Iout = 3A Vin = 20V, Vout = 5.0V	-	25	-	mVp-p
R_{DIS}	Output discharge resistance		-	5	-	kΩ
■ Control Characteristics						
V_{FB}	Feedback voltage		0.99	1	1.01	V
$R_{EN/COMP}$	EN/COMP_SEL logic low	$R_{EN/COMP}$ falling	-	-	14	kΩ
$I_{EN/COMP}$	EN/COMP_SEL Current		-	5	-	uA
R_{PGOOD}	Internal resistor between LDO output and PGOOD pins		-	100	-	kΩ
V_{PG-H}	PGOOD voltage High	PGOOD Open / No Fault	5.63	5.8	5.97	V
T_{SS}	Soft-Start time	From VOUT=0% to 100%	-	18	-	mS
F_{OSC}	Oscillator frequency		-	450	-	kHz
■ Fault Protection						
OCP	Over-current threshold	R_{SENSE} = 10mΩ	-	3.5	-	A
I_{LIM}	High side current limit protection		5	7	-	A
OVP	VOUT OVP Threshold	PGOOD from H to L	-	120	-	%
	VOUT OVP Release Threshold	PGOOD from L to H	-	117.5	-	%
UVP	VOUT UVP Threshold	PGOOD from H to L	-	80	-	%
	VOUT UVP Release Threshold	PGOOD from L to H	-	90	-	%
T_{SD}	Shutdown temperature		-	130	-	℃
T_{SDHYS}	Thermal shutdown hysteresis		-	20	-	℃

TYPICAL PERFORMANCE CHARACTERISTICS: (5 VOUT)

Conditions: TA = 25 ºC, unless otherwise specified. Test Board Information: 30mm×30mm×1.6mm, 4 layers 2Oz.
The output ripple and transient response measurement is short loop probing and 20MegHz bandwidth limited.
Cin = 10uF/50V/1210X 2, Cout = 22uF/25V/1210+56uF/25V (ESR:50mΩ) + 0.1uF/50V/0603, $R_{EN/COMP\_SEL}$=180kΩ
The following figures provide the typical characteristic curves at 5.0Vout.

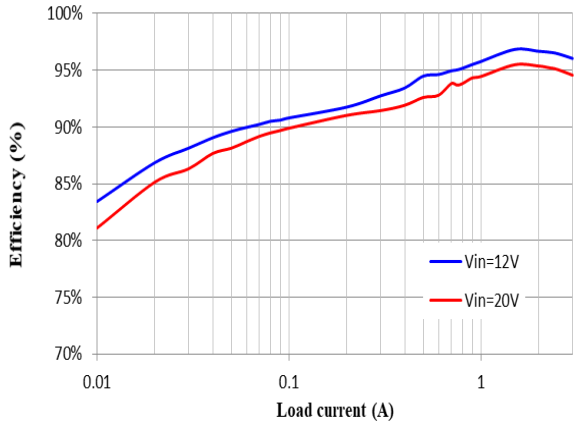


FIG.3 Efficiency V.S. Load Current

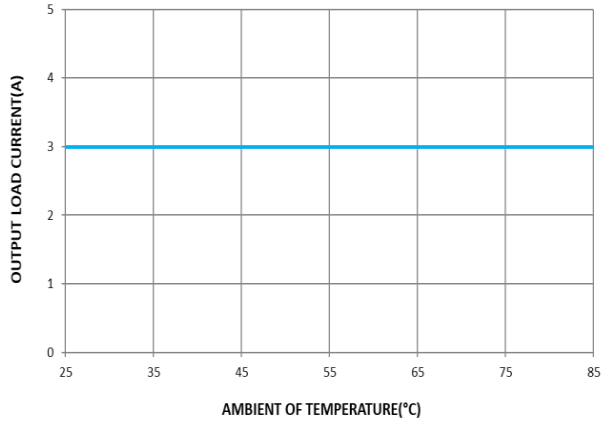


FIG.4 De-rating Curve

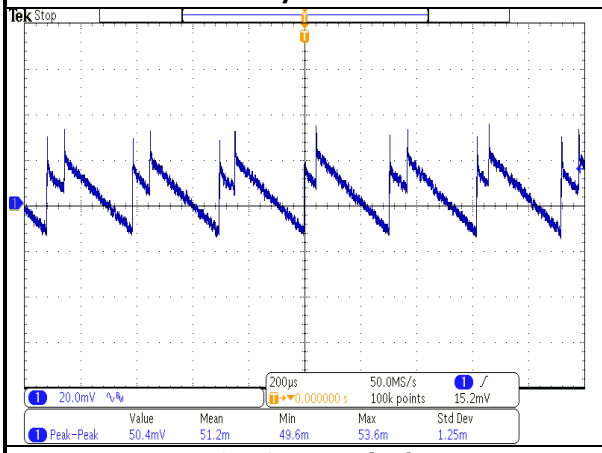


FIG.5 Output Ripple
(20Vin, Iout=10mA)

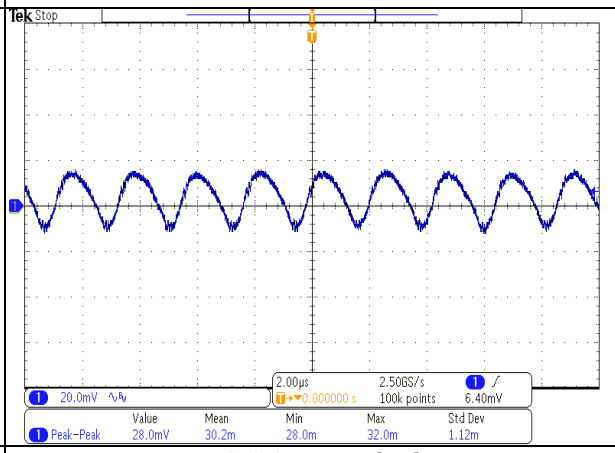


FIG.6 Output Ripple
(20Vin, Iout=3A)

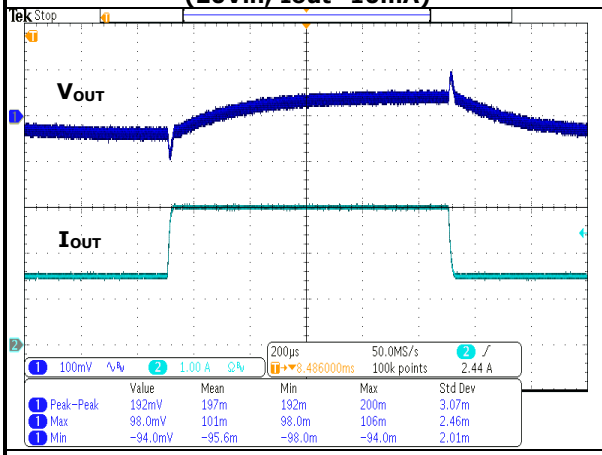


FIG.7 Transient Response
(20Vin, 50% to 100% Load Step)

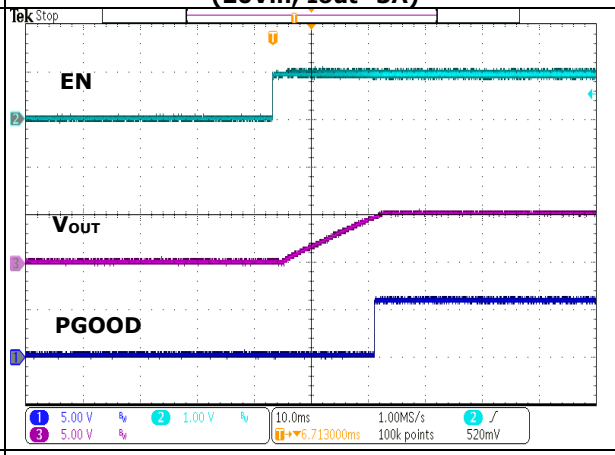


FIG.8 Turn-on
(20Vin, Iout=3A)

TYPICAL PERFORMANCE CHARACTERISTICS: (9.0 VOUT)

Conditions: TA = 25 ºC, unless otherwise specified. Test Board Information: 30mm×30mm×1.6mm, 4 layers 2Oz.
The output ripple and transient response measurement is short loop probing and 20MegHz bandwidth limited.
Cin = 10uF/50V/1210X 2, Cout = 22uF/25V/1210+56uF/25V (ESR:50mΩ) + 0.1uF/50V/0603, $R_{EN/COMP\_SEL}$=180kΩ
The following figures provide the typical characteristic curves at 9.0Vout.

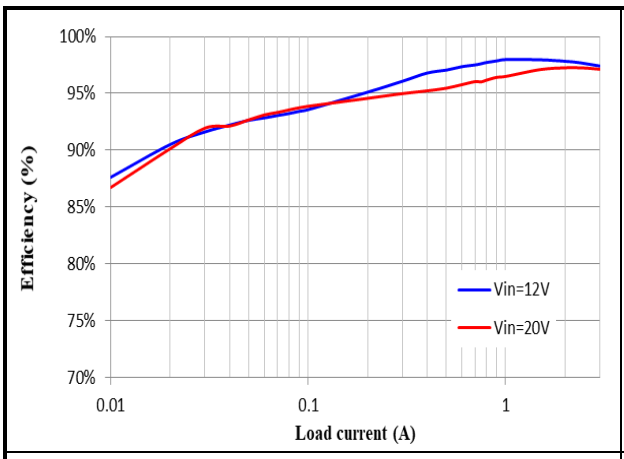


FIG.9 Efficiency V.S. Load Current

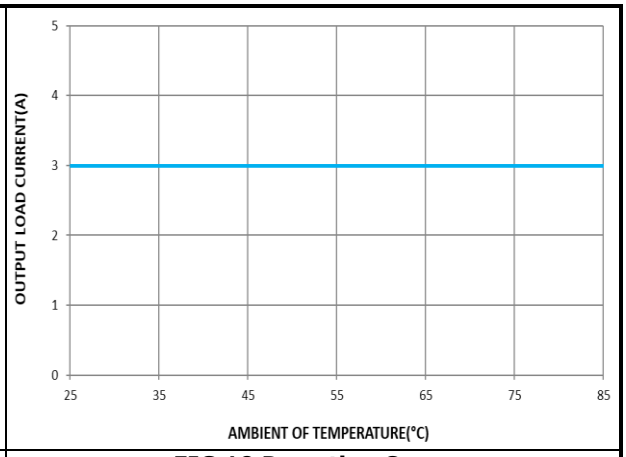


FIG.10 De-rating Curve

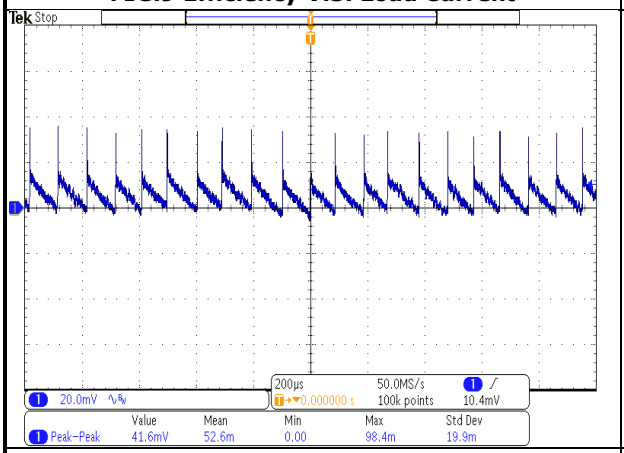


FIG.11 Output Ripple
(20Vin, Iout=10mA)

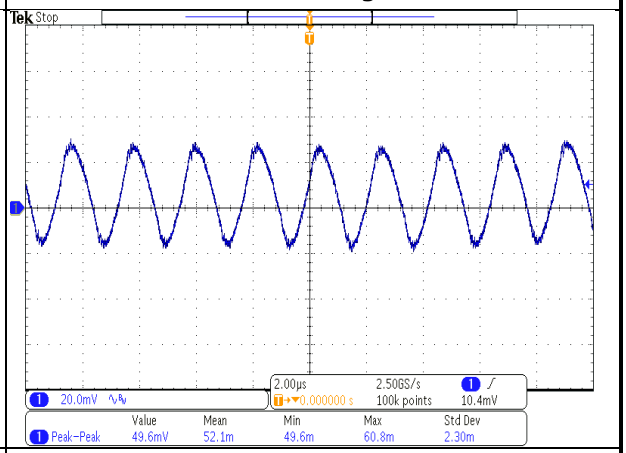


FIG.12 Output Ripple
(20Vin, Iout=3A)

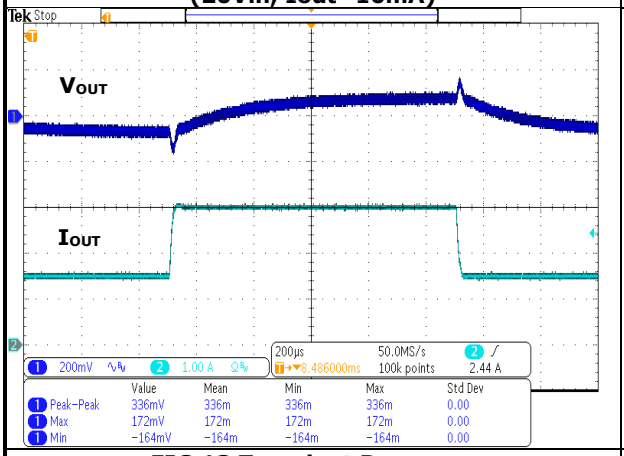


FIG.13 Transient Response
(20Vin, 50% to 100% Load Step)

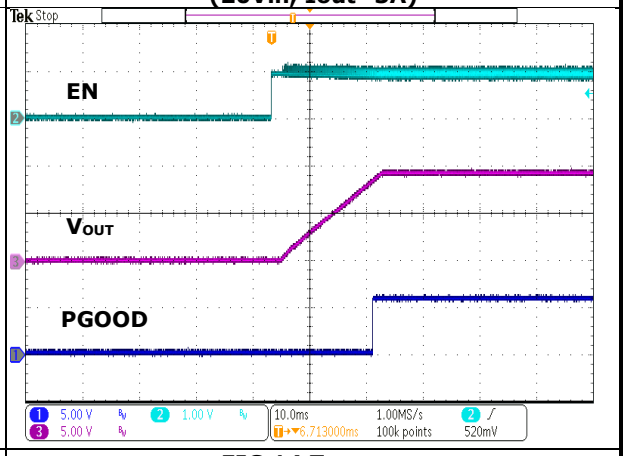


FIG.14 Turn-on
(20Vin, Iout=0A)

TYPICAL PERFORMANCE CHARACTERISTICS: (12.0 VOUT)

Conditions: TA = 25 ºC, unless otherwise specified. Test Board Information: 30mm×30mm×1.6mm, 4 layers 2Oz.
The output ripple and transient response measurement is short loop probing and 20MegHz bandwidth limited.
Cin = 10uF/50V/1210X 2, Cout = 22uF/25V/1210+56uF/25V (ESR:50mΩ) + 0.1uF/50V/0603, $R_{EN/COMP\_SEL}$=180kΩ
The following figures provide the typical characteristic curves at 12.0Vout.

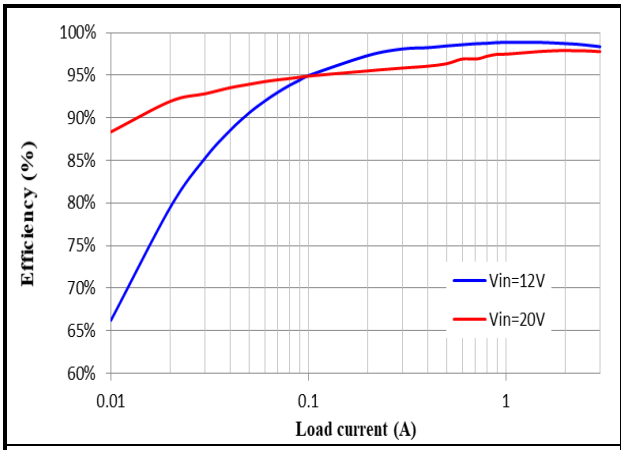


FIG.15 Efficiency V.S. Load Current

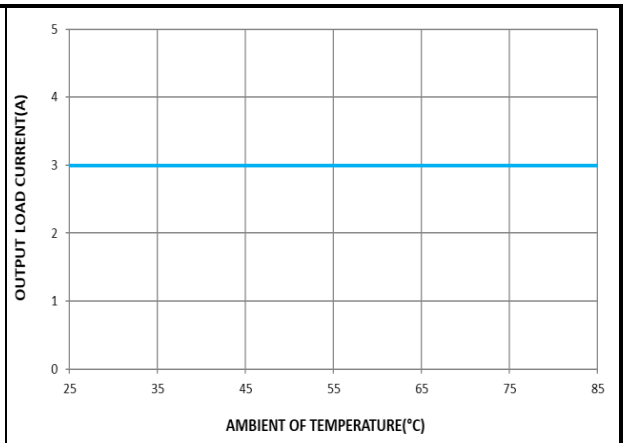


FIG.16 De-rating Curve

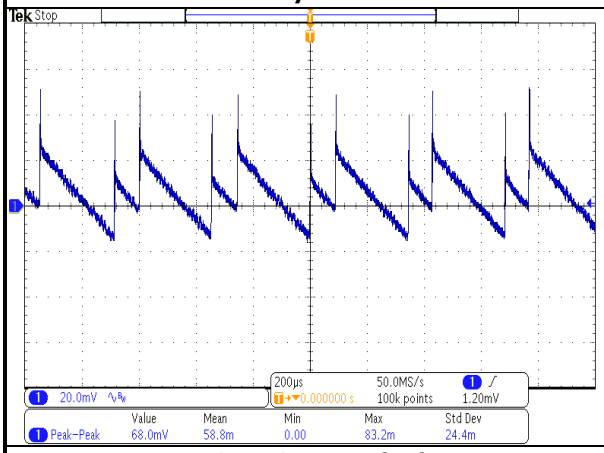


FIG.17 Output Ripple
(20Vin, Iout=10mA)

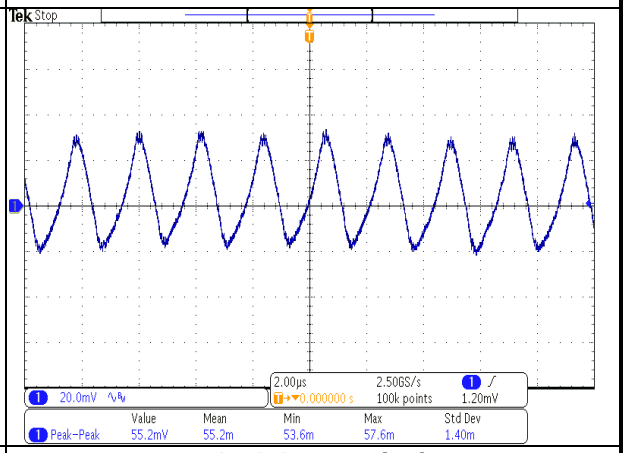


FIG.18 Output Ripple
(20Vin, Iout=3A)

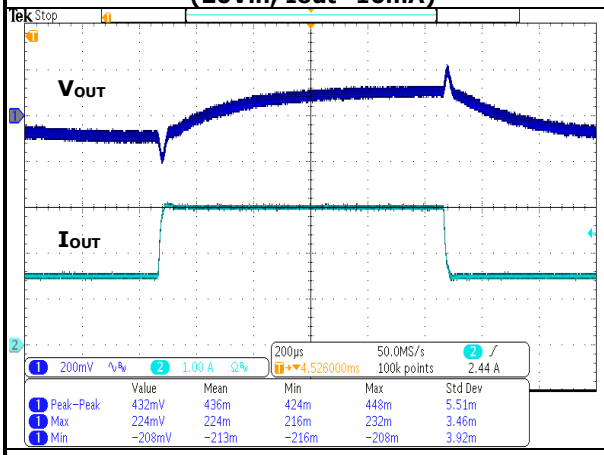


FIG.19 Transient Response
(20Vin, 50% to 100% Load Step)

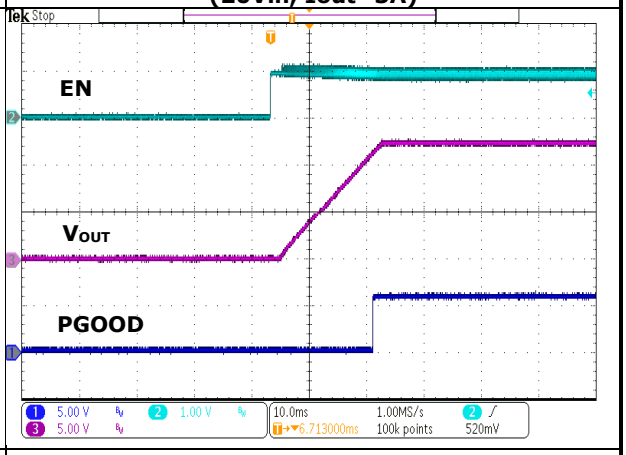


FIG.20 Turn-on
(20Vin, Iout=0A)

TYPICAL PERFORMANCE CHARACTERISTICS: (20.0 VOUT)

Conditions: TA = 25 ºC, unless otherwise specified. Test Board Information: 30mm×30mm×1.6mm, 4 layers 2Oz.
The output ripple and transient response measurement is short loop probing and 20MegHz bandwidth limited.
Cin = 10uF/50V/1210X 2, Cout = 22uF/25V/1210+56uF/25V (ESR:50mΩ) + 0.1uF/50V/0603, $R_{EN/COMP\_SEL}$=180kΩ
The following figures provide the typical characteristic curves at 20.0Vout.

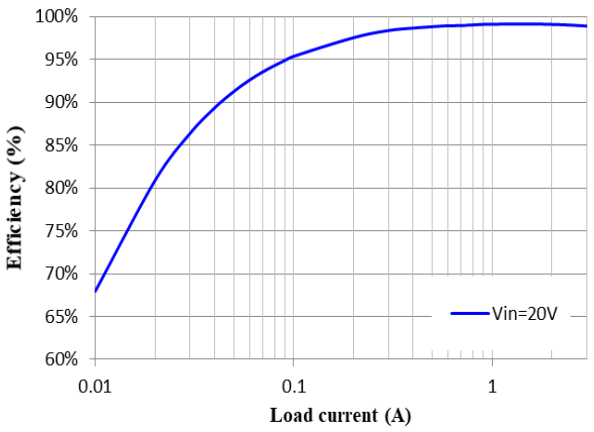


FIG.21 Efficiency V.S. Load Current

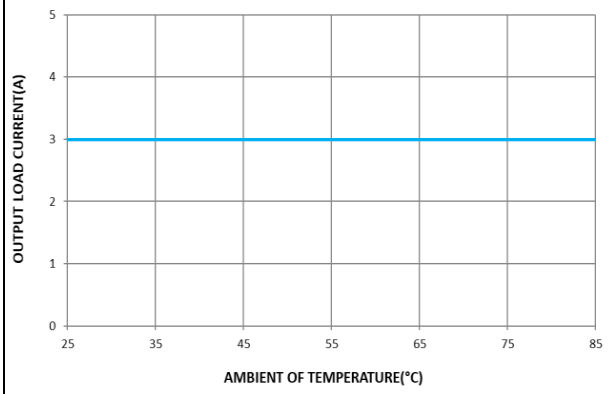


FIG.22 De-rating Curve

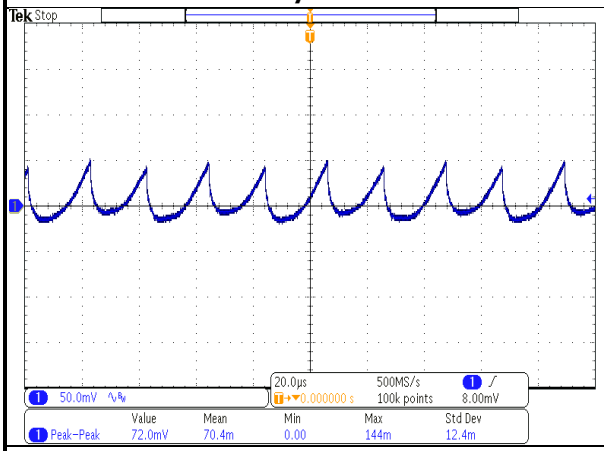


FIG.23 Output Ripple
(20Vin, Iout=10mA)

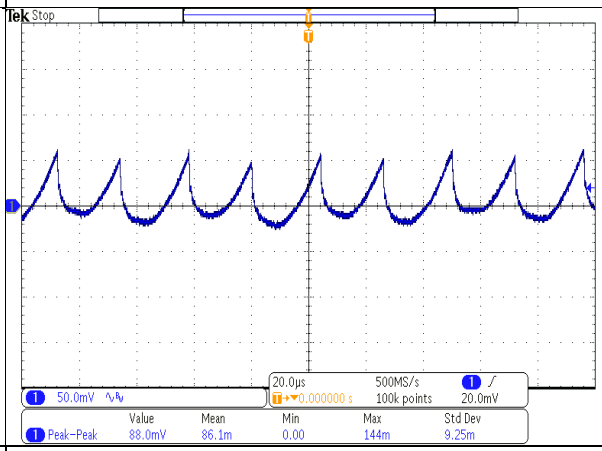


FIG.24 Output Ripple
(20Vin, Iout=3A)

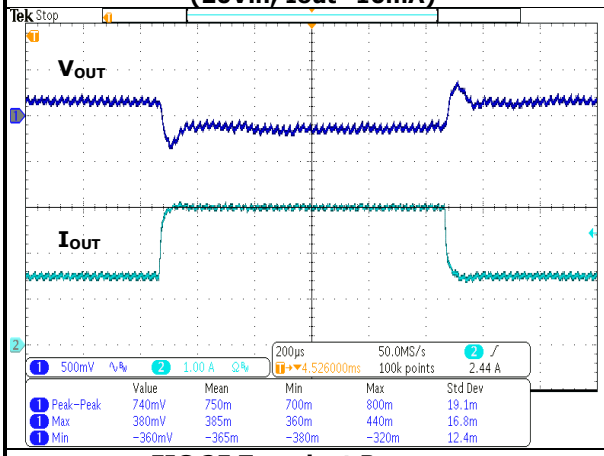


FIG.25 Transient Response
(20Vin, 50% to 100% Load Step)

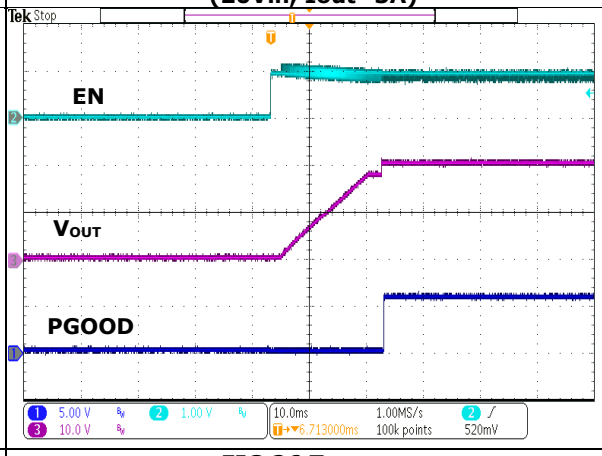


FIG.26 Turn-on
(22Vin, Iout=0A)

APPLICATIONS INFORMATION:

Output Line-drop Compensation

In charger applications, the large load will cause voltage drop in the output cable. The module has a built-in cable compensation function. The adjustable Line Compensation (mV)/A is set according to the following equation 1:

$$I_{OUT} \times R_{SENSE} \times k \times \left[\frac{(R_{FB\_T}+R_{FB\_B})}{R_{FB\_B}}\right] \quad \text{(EQ.1)}$$

When $R_{EN/COMP\_SEL} = 360k\Omega \ \ or \ \ Floating \ \ , k = 0.8$

$R_{EN/COMP\_SEL} = 180k\Omega \ \ , k = 1.2$

$R_{EN/COMP\_SEL} = 91k\Omega \ \ \ , k = 1.6$

$R_{EN/COMP\_SEL} = 43k\Omega \ \ \ , disable \ \ Line \ \ Compensation$

PROGRAMMING OUTPUT VOLTAGE:

The module has an internal 1V±1.0% reference voltage. The output voltage can be programmed by the dividing resistor (R_{FB_T} and R_{FB_B}). The output voltage can be calculated by Equation 2, resistor choice may be referred to TABLE 1.

$$V_{OUT} = 1 \times \left(1 + \frac{R_{FB\_T}}{R_{FB\_B}}\right) \quad \text{(EQ.2)}$$

$$R_{FB\_B} \leq 100k\Omega \ \ , \text{at} \ \ V_{OUT} = 3.3V \sim 21V$$

TABLE 1 Resistor values for common output voltages

VOUT (V)	R_{FB_T}(kΩ)	R_{FB_B}(kΩ)
3.3	57.5	25
5.0	100	25
9.0	200	25
12.0	275	25
20.0	475	25

APPLICATIONS INFORMATION: (Cont.)

Output Over Current Limit

The Output Current limit is set at 3.5A by default with an external resistance R_{SENSE} =10mΩ, When the (CSP_OUT) - (CSN_OUT) voltage gets higher than 35mV and reaches the current limit, the driver is turned off. MPN24AD03-UP-T provides the lower output over current protection by external sense resistor, R_{sense}. Please refer to below equation 3 to get the lower limit.

$$I_{OCP} = 35mV / \ R_{SENSE} \quad \text{(EQ.3)}$$

REFLOW PARAMETERS:

Lead-free soldering process is a standard of electronic products production. Solder alloys like Sn/Ag, Sn/Ag/Cu and Sn/Ag/Bi are used extensively to replace the traditional Sn/Pb alloy. Sn/Ag/Cu alloy (SAC) is recommended for this power module process. In the SAC alloy series, SAC305 is a very popular solder alloy containing 3% Ag and 0.5% Cu and easy to obtain. Figure 46 shows an example of the reflow profile diagram. Typically, the profile has three stages. During the initial stage from room temperature to 150°C, the ramp rate of temperature should not be more than 3°C/sec. The soak zone then occurs from 150°C to 200°C and should last for 60 to 120 seconds. Finally, keep at over 217°C for 60 seconds limit to melt the solder and make the peak temperature at the range from 240°C to 250°C. It is noted that the time of peak temperature should depend on the mass of the PCB board. The reflow profile is usually supported by the solder vendor and one should adopt it for optimization according to various solder type and various manufacturers' formulae.

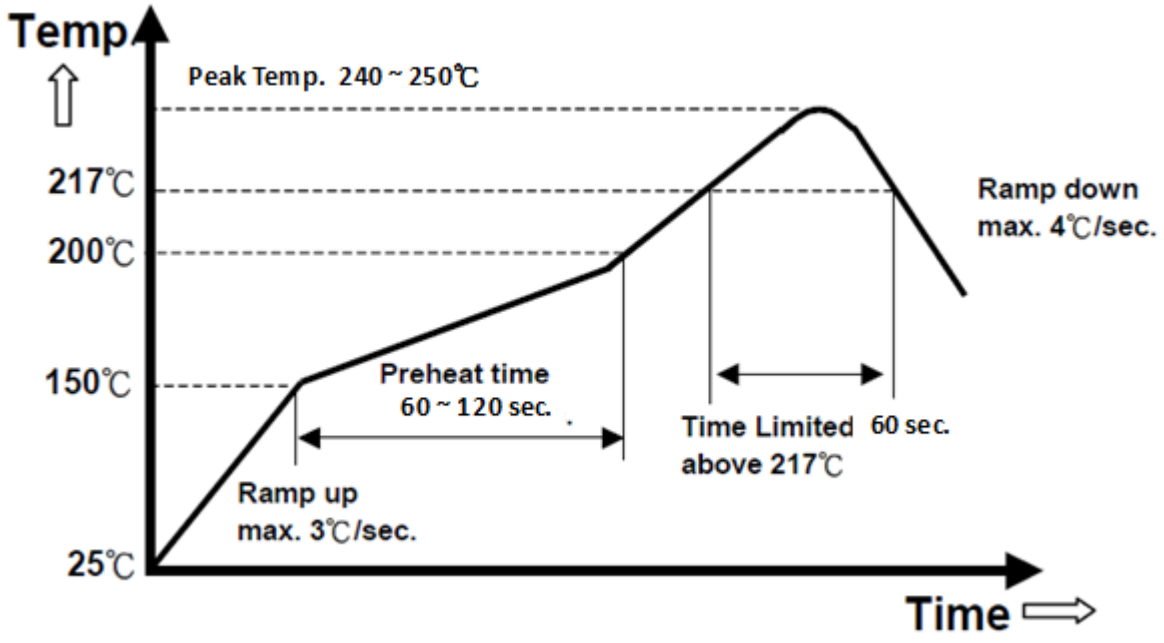
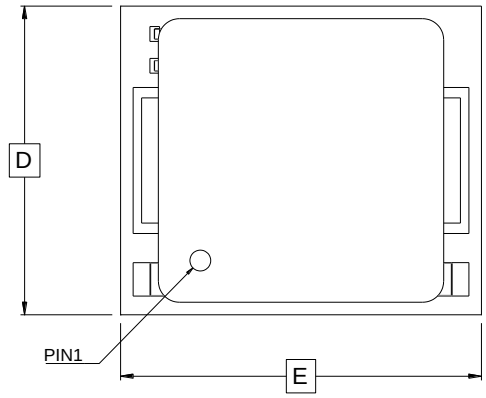


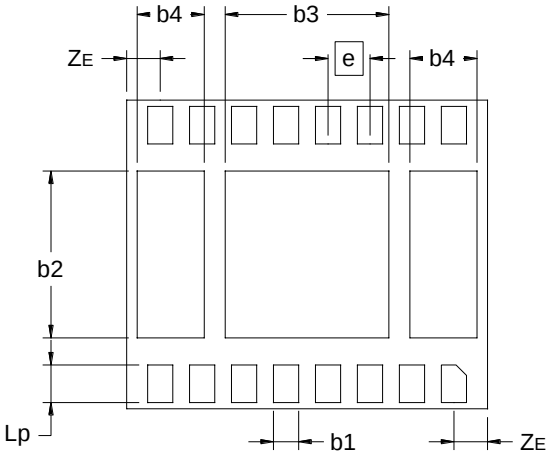
FIG.46 Recommendation Reflow Profile

PACKAGE OUTLINE DRAWING:

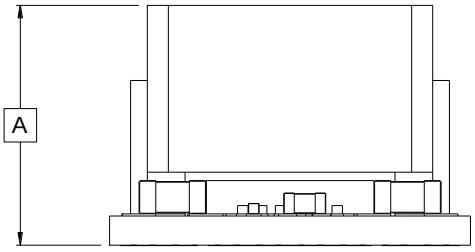
Unit: mm



Top View



Bottom View



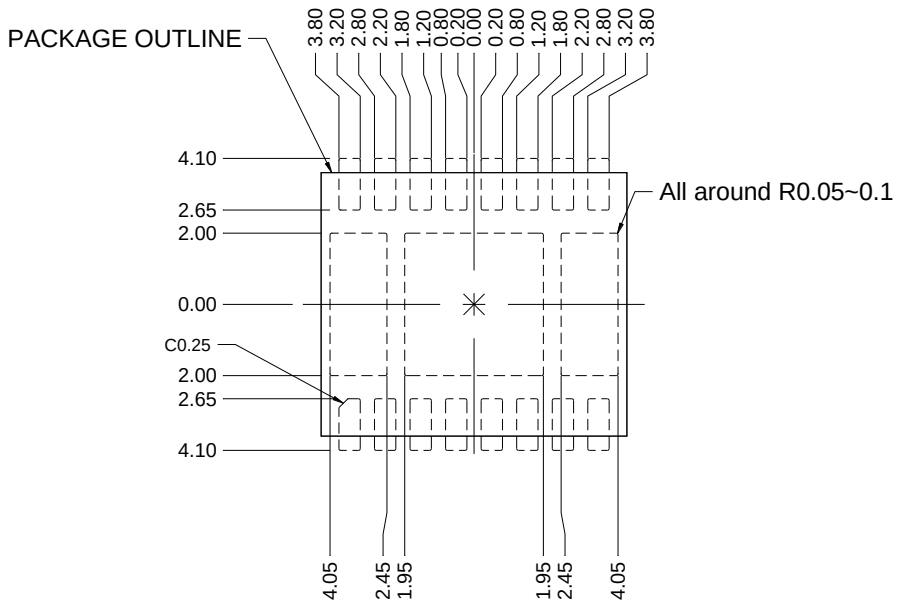
Side View

DIM	MILLIMETERS		
	MIN	NOM	MAX
A	-	-	6.0
D	7.2	7.4	7.6
E	8.4	8.6	8.8
e	0.95	1.0	1.05
ZE	0.7	0.8	0.9
Lp	0.85	0.9	0.95
b1	0.55	0.6	0.65
b2	3.95	4.0	4.05
b3	3.85	3.9	3.95
b4	1.55	1.6	1.65

PACKAGE OUTLINE DRAWING:

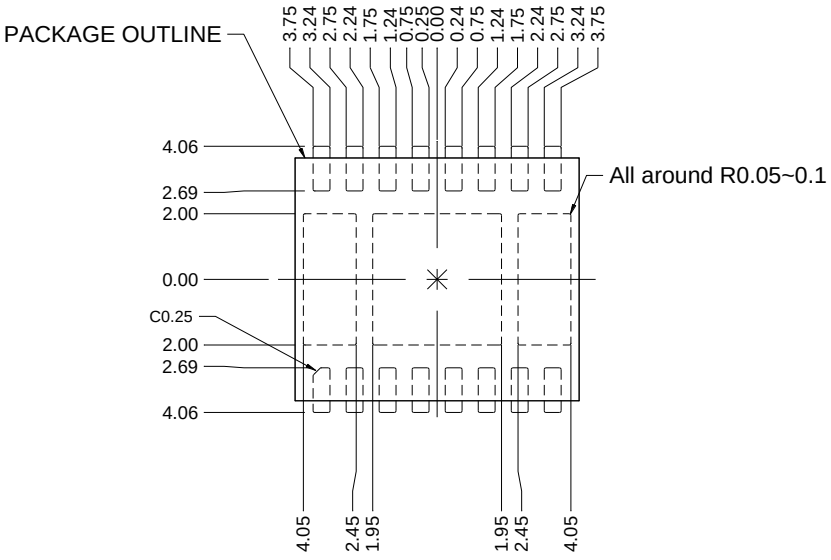
Unit: mm

General Tolerances:±0.2mm



TOP VIEW

TYPICAL RECOMMENDED LAND PATTERN



STENCIL THICKNESS RECOMMEND = 0.1mm

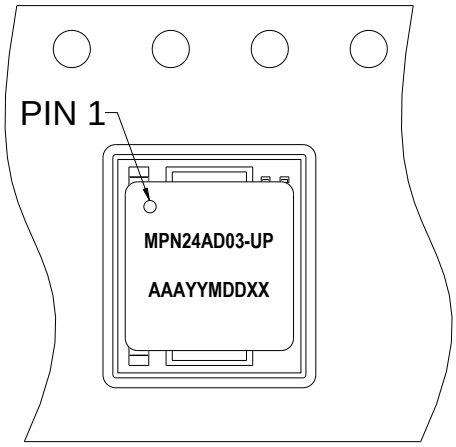
TOP VIEW

STENCIL PATTERN WITH PADS

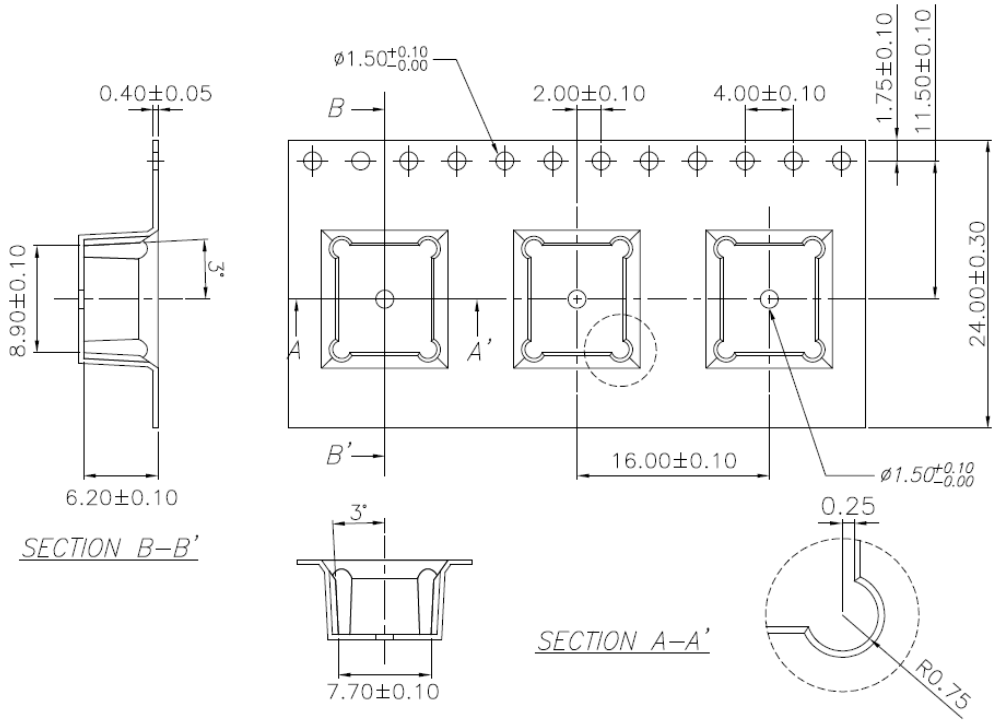
PACKING INFORMATION:

Unit: mm

Tape And Reel Packing



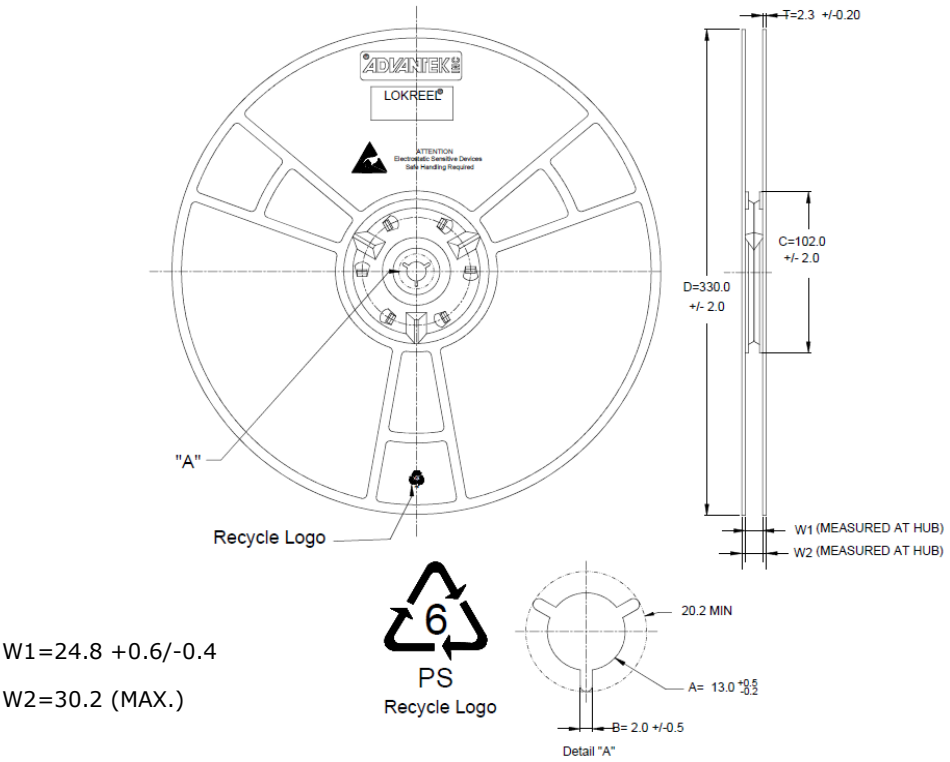
Package In Tape Loading Orientation



Carrier Tape Dimension

PACKING INFORMATION: (Cont.)

Unit: mm



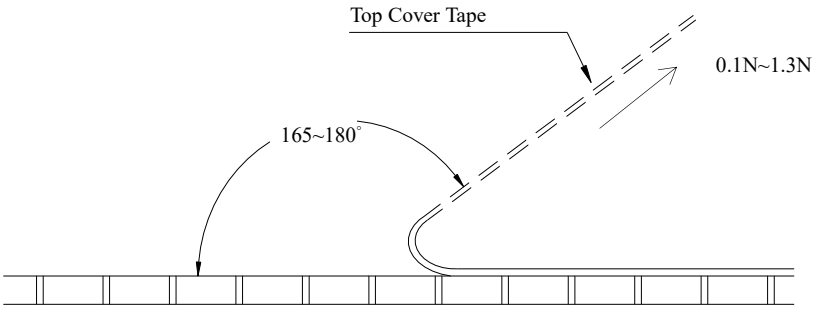
W1=24.8 +0.6/-0.4

W2=30.2 (MAX.)

Reel Dimension

The peel speed shall be about 300mm/min.

The peel force of top cover tape shall between 0.1N to 1.3N



Peel Strength of Top Cover Tape

REVISION HISTORY:

Date	Revision	Changes
20200219	00	Release the preliminary specification.
20200814	01	Add PGOOD function
20201215	02	Modify Land Patter and Stencil Pattern information
20210331	03	Modify Output ripple and Efficiency