AP2965

Chipown

High Performance Synchronous CV/CC Buck Converter

General Description

AP2965 is a High Efficiency Synchronous DC-DC Buck Converters with CV / CC modes, which can output up to 4.2 A in a wide input range from 6 V to 38 V. The AP2965 operates either in CV (Constant Voltage) mode or CC (Constant Current) mode. With the CV / CC mode, adjustable current limit and output voltage, the AP2965 is particularly suitable for QC 2.0 / 3.0 (12 V / 1.5 A, 9 V / 2 A and 5 V / 3 A), Type-C PD (5 V / 3 A) and Apple portable device (5 V / 2.4 A) applications. The output voltage and CC limit can be programed through the FB, CSP and CSN pins respectively.

In order to achieve better EMI performance and comply with Apple's MFi standard, the switching frequency was fixed at 125 kHz. AP2965 is capable to operate in CC mode down to 3 V output voltage to protect the soft-short condition that is from the over current of the portable device

A discharge circuitry is integrated to quickly and reliably discharge output capacitors to avoid the faulty voltage delivery in case of output over voltage and ensure safe operation for QC 2.0 / 3.0 application. The hiccup mode output Under Voltage Protection(UVP) can reduce the average input current to 50 mA. Features such as output cord voltage drop compensation and low voltage drop operation is especially suitable for car charger. AP2965 is available in SOP8-EP package which is beneficial for compact solution as well as thermal dissipation.

Applications

- Car Charger
- Portable Charging Devices
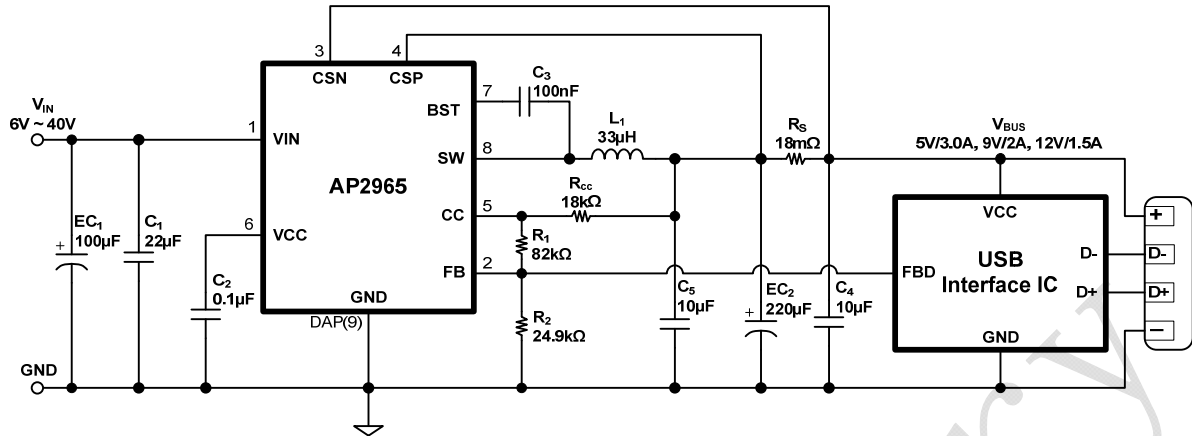- CV / CC regulation DC / DC converter
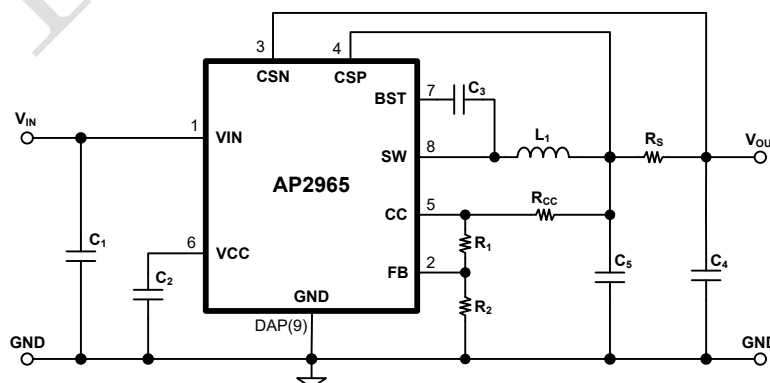
Features

- Wide Input Supply Voltage Range of 6 V ~ 38 V
- Up to 4.2 A Output Current
- Up to 95 % Efficiency
- 125 kHz Fixed Switching Frequency
- Internal Soft Start Circuitry
- Compensation for Output Cord Voltage Drop
- Input Under Voltage Lockout
- Input Over Voltage Protection
- Adjustable Constant Current Limit
- Output Over Voltage Protection
- Output Auto Discharge
- Cycle by Cycle Peak Current Limit
- Hiccup Mode Output UVP for Soft-short ≤ 3 V
- Thermal Shutdown
- Thermally Enhanced SOP8-EP Package

Typical Application Efficiency

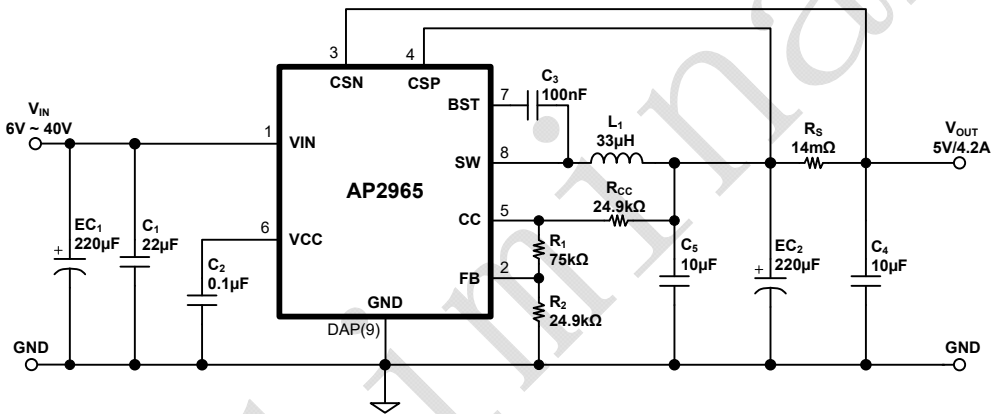### Simplified Application Circuit
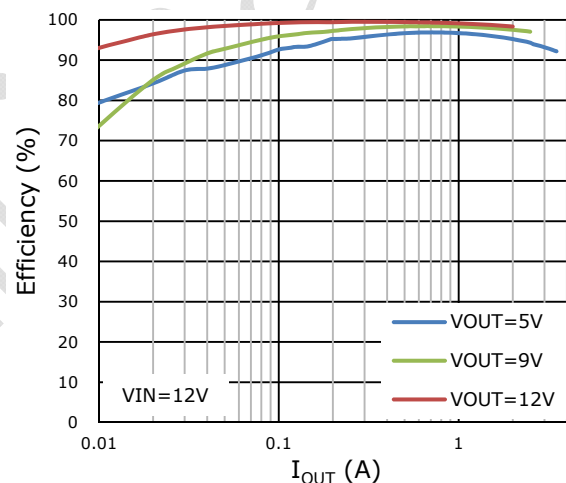
Typical Application Circuit with USB Interface IC

Typical Application Circuit for High Current Output

*The purpose of this Preliminary Information is to confirm features and specifications. It does not imply a product under development or any commitment to do so. All features, part number and specification are subject to change.

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Ordering Information

Order Code	Shipping	Top Marking
AP2965SPER	TBD/Reel	AP2965 YYWWP[1]

(1). XY = Date code, P = Assembly site

Pin Configuration

Top View

VIN — SW
FB — BST
CSN — GND — VCC
CSP — Thermal Pad — CC

SOP8-EP
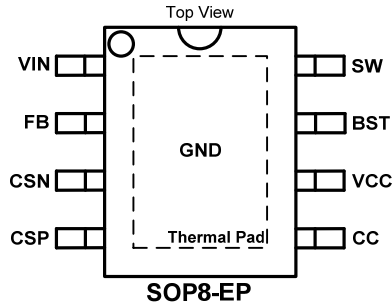
Pin Description

| Pin No.	Pin Names	Pin Functions
1	VIN	Input Voltage Supply. Connect a decoupling capacitor between VIN and GND pins with least distance.
2	FB	Converter feedback input. Connect to the center point of the output feedback resistors divider to program the output voltage.
3	CSN	Current Limit Negative Feedback pin. Kevin sensing from this pin to the sensing resistor is recommended.
4	CSP	Current Limit Positive Feedback pin. Kevin sensing from this pin to the sensing resistor is recommended.
5	CC	Cable Compensation pin. Connect a resistor to output to adjust wire compensation gain.
6	VCC	Internal 5V Power Supply. Connect a 100nF capacitor between VCC and GND pins for stability and noise de-coupling;
7	BST	Boot-Strap pin. Supply input for the gate drive circuit of high-side NFET. Connect a 100 nF capacitor between BST and SW pins.
8	SW	Switch Node between high-side NFET and low-side NFET. Connect this pin to the switching node of inductor.
DAP(9)	GND	Ground and Thermal Pad on the bottom of IC. Ground pin of internal circuitry and Power Return Pin for Sync-NFET source connection.

Functional Block Diagram
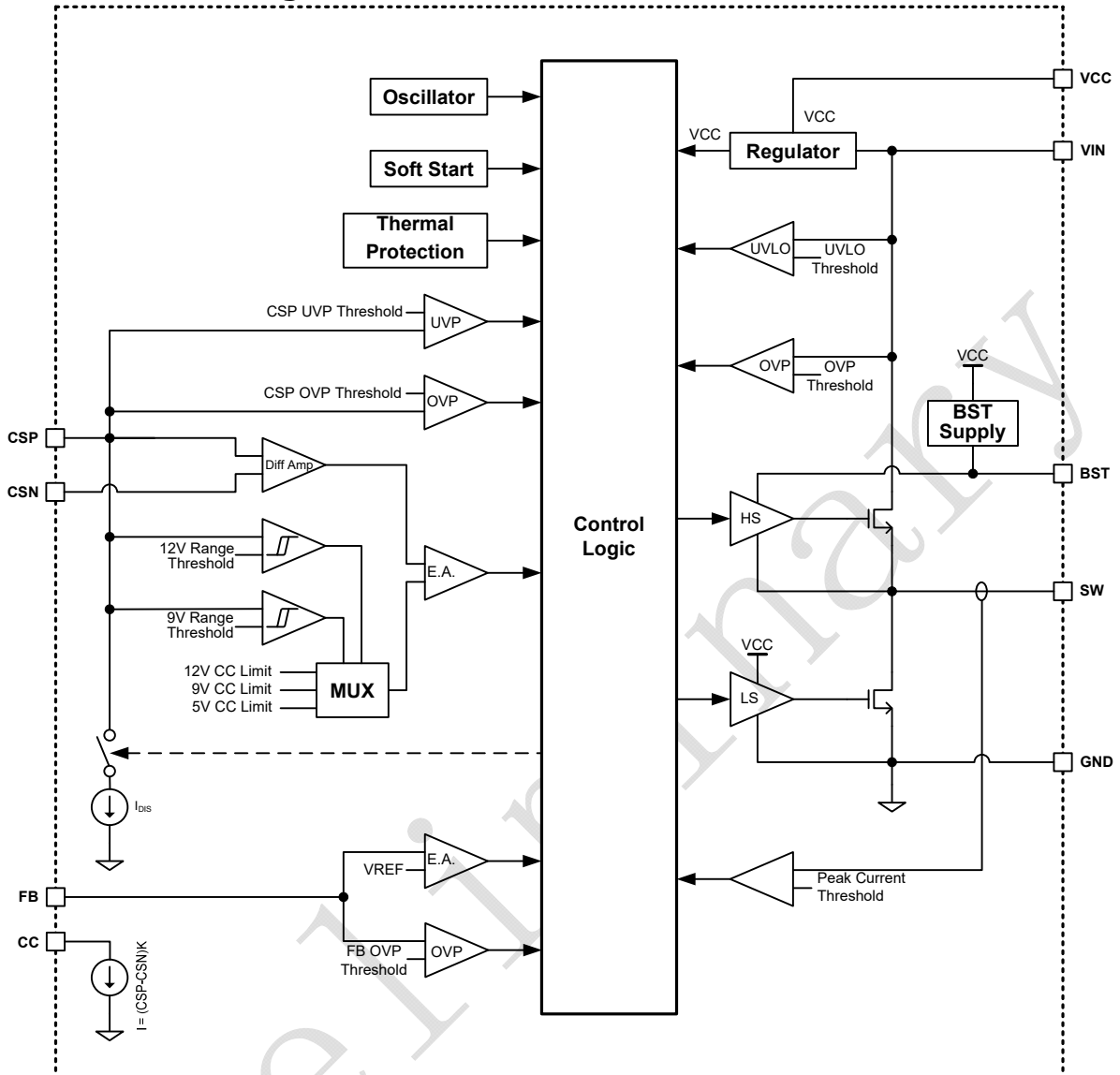
Figure 1.   Functional Block Diagram

Absolute Maximum Ratings[1]

VIN..-0.3 V ~ 42 V
SW...................-0.3 V ~ (V_{IN} + 0.2 V) ≤ 42 V
BST to SW.................................-0.3 V ~ 6 V
CSP, CS, CC............................-0.3 V ~ 14 V
VCC, FB...................................-0.3 V ~ 6 V
ESD Rating (Human Body Model)........±4 kV[2]

Package Thermal Resistance[3]
  Θ_{JA}.......................................TBD°C/W
Min. Operating T_J...............................-40 °C
Max. Operating T_J.................Internally Limited
Storage Temperature............ -55 °C ~ 150 °C
Lead Temperature (Soldering 10 sec.)....260 °C

(1). All voltages refer to GND pin unless otherwise noted; Stresses exceed those ratings may damage the device.
(2). Tested and classified as Class 3A per ESDA/JEDEC JDS-001-2014.
(3). Thermal Resistance is measured in the natural convection at T_A = 25 °C on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

Electrical Characteristics[1]

(V_{IN} = 12V, T_A = 25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Supply Voltage						
Input Voltage	V_{IN}		6		38	V
Input UVLO & OVP						
UVLO Threshold	V_{UVLO}	V_{IN} Rising		4.5		V
UVLO Hysteresis	$V_{UVLOHYS}$	V_{IN} Falling		500		mV
OVP Threshold	V_{IN_OVP}	V_{IN} Rising	37	38	39	V
OVP Hysteresis	V_{IN_OVPHYS}	V_{IN} Falling		1		V
Input Supply Current						
Quiescent Current(non-switching)	I_Q	V_{FB} = 1 V		500	1000	µA
Shutdown Supply Current	I_{SHDN}	V_{OUT} = 5 V		1		µA
Output Voltage						
Output Voltage Range	V_{OUT}		3.2		13.5	V
Feedback Voltage Threshold	V_{FB_TH}		0.98	1	1.02	V
Feedback Current	I_{FB}			1	50	nA
CSP OVP Threshold	V_{CSP_OVP}	V_{CSP} Rising	13.8	14.8	15.8	V
CSP OVP Hysteresis	V_{CSP_HYS}	V_{CSP} Falling	300		600	mV
CSP OVP delay[2]	T_{CSPOVP_DLY}			TBD		ns
Feedback OVP Threshold	V_{FB_OVP}	V_{FB} Rising, % of V_{FB_TH}		110		%
Feedback OVP Threshold Hysteresis	V_{FB_HYS}	V_{FB} Falling, % of V_{FB_TH}		5		%
Feedback OVP delay[2]	T_{FBOVP_DLY}			200		ns
CSP UVP Threshold	V_{UVP}	V_{CSP} Falling	2.94	3.00	3.06	V
UVP Hiccup Interval	T_{UVP}			1		s
Cable Compensation Voltage at Output	V_{CCOMP}	R_{CC} = 18 kΩ, I_{LOAD} = 2.4 A, R_S = 18 mΩ		150		mV
Auto Discharge Threshold	V_{TH_DIS}	% of V_{FB_TH}		110		%
Auto Discharge Current	I_{DIS}			50		mA
Oscillator						
Switching Frequency	F_{SW}	I_{LOAD} = 0.1 A	105	125	145	kHz
Maximum Duty Cycle	D_{MAX}			99		%
Minimum ON time	T_{ONMIN}	V_{FB} = 0.7 V		120		ns

MOSFET						
High Side MOSFET On Resistance[1]	$R_{DS(ON)H}$			40		mΩ
Low Side MOSFET On Resistance[1]	$R_{DS(ON)L}$			30		mΩ
High-Side MOSFET Leakage Current	I_{LEAK_H}	$V_{SW} = 0\ V$			10	µA
Low-Side MOSFET Leakage Current	I_{LEAK_L}	$V_{SW} = V_{IN}$			10	µA
Current Limit						
High Side MOSFET Peak Current Limit	I_{LIM_HS}	$V_{OUT} = 5\ V$, $T_A = -40 \sim 85^oC$	6.0	6.3	6.6	A
Constant Current Limit Threshold	I_{CS}	$R_S = 13.5\ mΩ$, $V_{OUT} = 5\ V$	4.255	4.479	4.703	A
		$R_S = 18\ mΩ$, $V_{OUT} = 5\ V$	3.088	3.250	3.413	A
		$R_S = 18\ mΩ$, $V_{OUT} = 9\ V$	2.058	2.167	2.276	A
		$R_S = 18\ mΩ$, $V_{OUT} = 12\ V$	1.543	1.625	1.707	A
Regulator						
VCC Regulator	V_{VCC}	$I_{LOAD} = 5\ mA$	4.9	5	5.1	V
VCC Current Limit	I_{LIM_VCC}			20		mA
Soft-start						
Soft-start Time	T_{SS}			2		ms
Thermal Shutdown						
Thermal Shutdown Threshold[2]	T_{SDN}			165		°C
Thermal Shutdown Hysteresis[2]	T_{SDNHYS}			30		°C

(1). Specifications over temperature range are guaranteed by design and characterization.
(2). Guaranteed by design and characterization only.

AP2965

Functional Descriptions

Operation

The AP2965 is a monolithic high efficiency synchronous buck converters with CV / CC modes. It utilizes internal MOSFETs to achieve high efficiency and up to 4.2 A output current in a wide input range from 6 V to 40 V. The output voltage and constant current limit can be programed through the FB, CSP and CSN pins respectively. The AP2965 is capable to operate in CC mode down to 2.5 V output voltage to protect the soft-short condition that is from the over current of the portable device.

With the slope compensated current mode PWM control, provides stable switching and cycle-by-cycle current limit for excellent load and line responses and protection of the internal switches. During normal operation, the internal main switch is turned on for a certain time to ramp up the inductor current at each rising edge of the internal oscillator, and turned off when the peak inductor current is above the error voltage. The current comparator limits the peak inductor current. Once the main switch is turned off, the synchronous rectifier will be turned on immediately and stay on until either the inductor current decay to zero, as indicated by the zero current comparator or the beginning of the next clock cycle.

Compensation for Output Cord Voltage Drop

In charger applications, the voltage drop across the output cord is significant in high current charging process. In some cases, excessive voltage drop across the output cord will even extend the charging time if high impedance output cord is used. The AP2965 integrated a cable compensation function. When the output current increases, the CC pin sinks current into the IC to increase the voltage drop across the resistor, R_{CC}, in order to increase the output voltage. The sinking current of the CC pin is proportional to the voltage across CSP and CSN pins. Thus, the cable compensation function can increase the output voltage according to the load. This increment of output voltage is called Cable Compensation Voltage(V_{CCOMP}). The value of R_{CC} determines the gain of the cable compensation. After taking the voltage drop across the sensing resistor, R_S, the value of R_{CC} can be calculated using Equation 1.

$$R_{CC} = \frac{V_{CCOMP} + I_{OUT} \times R_S}{(I_{OUT} \times R_S - V_{OS})K} \qquad (1)$$

Where

- R_{CC} is the value of the resistor between CC pin and the node of the inductor.

- V_{CCOMP} is the cable compensation voltage measured at the output.
- I_{OUT} is the output current of the converter.
- V_{OS} is the internal offset voltage which is equal to 4.87 mV
- K is a constant which is equal to 280 μ.
- R_S is the value of the sensing resistor.

Programmable CV / CC Mode Control

The AP2965 features a CV / CC function. It operates either in CV mode or CC mode. The CV and the CC limits can be programed through FB, CSP and CSN pins respectively. With the programmable output voltage and constant current limit. The device is particularly suitable for QC 2.0, QC 3.0 Type-C PD and Apple portable device applications.

The CC mode provides an accurate current limiting function which is programed through the sensing resistor, R_S. Output current can increase until it reaches the CC limit set by the sensing resistor. At this point, the AP2965 will transit from regulating output voltage to regulating output current, and the output voltage will drop with increasing load. The AP2965 can output up to 4.2 A current at 5 V output voltage. In general, 3 A output current is sufficient for charging purpose. **Figure 2** shows the CC limit at 5 V output voltage verse sensing resistor, R_S. In this case, the CC limit should be set at a level which is slightly higher than 3 A. A 18 mΩ sensing resistor should be selected for ensuring 3 A continuous output current. The CC limit is adaptive at different output voltages which is particularly useful in QC 2.0 / 3.0 application.
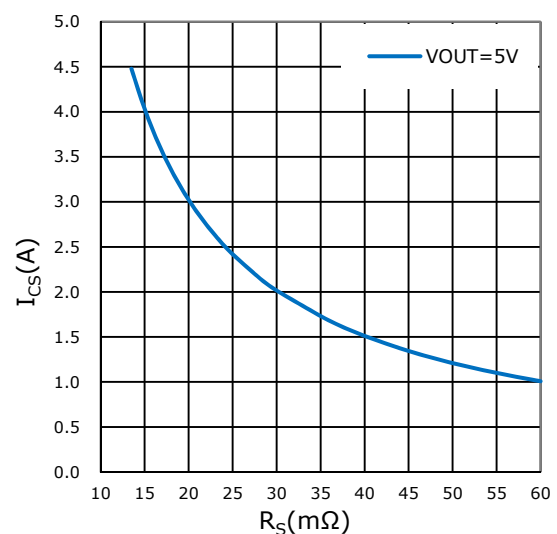

Figure 2. CC Limit vs. R_S

In CV mode, the feedback voltage is regulated at 1 V and the output voltage is programed by the feedback divider R_{CC}, R_1 and R_2. R_{CC} and R_1 together form the upper feedback resistor and R_3 is the lower feedback resistor. The output voltage at no load can be calculated using Equation 2.

$$V_{OUT} = \frac{(R_{CC}+R_1)+R_2}{R_2} \qquad (2)$$

where

- V_{OUT} is the output voltage at no load.
- R_{CC} is the value of the resistor between CC pin and the node of the inductor.
- R_1 is the value of the resistor between CC and FB pins.
- R_2 is the value of the resistor between FB and GND pins.

Cycle by Cycle Peak Current Limit

The peak current limit prevents the AP2965 from high inductor current and from drawing excessive current from the input voltage rail. Excessive current might occur with a shorted or saturated inductor or a heavy load or shorted output circuit condition. If the inductor current reaches the peak limit threshold, the high-side MOSFET is turned off and the low-side MOSFET is turned on to ramp down the inductor current.

Output Auto Discharge

The AP2965 is designed for working with USB Interface IC (QC 2.0 / 3.0). Regarding to the output voltage changing capability of this application, the AP2965 integrates an output auto discharge path to discharge the output capacitor at 50 mA typically once the voltage at the FB pin raise above 110 % of feedback voltage threshold. The function is crucial in high voltage charging scheme.

For instant, the output capacitor is charged-up by the high voltage which is set by the portable device. After the portable device is unplugged, the output capacitor takes time to be discharged if there is no high current discharge path. There is a chance that a conventional 5 V portable device is damaged by a high voltage once it is connected to the power supply immediately after the detachment of QC 2.0 / 3.0 portable device.

Input Under-voltage Lockout(UVLO)

An input UVLO circuit prevents the converter from starting the operation until the input voltage rises above the typical UVLO threshold of 4.5 V. A hysteresis of 500 mV is added so that the device cannot be disabled again until the input voltage drops below 4 V. This function is implemented in order to prevent malfunctioning of the device when the input voltage is between 4 V and 4.5 V.

Input Over Voltage Protection(OVP)

The input OVP is an additional function to protect the device from damage in a condition which is above the specified input voltage range. Once the input voltage is raising above input OVP threshold, 38 V typically, the AP2963 stops switching to reduce the chance of damage by the voltage spike at SW pin. The device goes back to normal operation until the input voltage falls a hysteresis about 1 V below the input OVP threshold.

Output Over Voltage Protection(OVP)

There are two individual output OVP functions in the AP2965. Those are CSP OVP and FB OVP. The CSP OVP senses the output voltage directly. If the voltage at CSP pin is detected above CSP OVP threshold of 14.8 V(typ.), the device stops switching immediately until the voltage at the CSP pin drops the hysteresis voltage lower than CSP OVP threshold. This function prevents the device as well as the output capacitors from damage by high voltage on the output even though the feedback resistors are faulty opened. The operation of FB OVP is very similar to the CSP OVP except that it detects the voltage of the FB pin(V_{FB}). Once V_{FB} raises above 110 % of the feedback voltage threshold, the FB OVP will be triggered immediately and stop switching. This OVP condition will be remove until V_{FB} drop hysteresis percentage lower than FB OVP threshold.

Hiccup Mode Output Under Voltage Protection(UVP)

There is a CSP UVP threshold. If the threshold is hit, the hiccup mode output UVP will be triggered by disabling the converter and restarts soft-start after a predefined interval about 1 s. The AP2965 repeats this mode until the under voltage condition is removed. This function prevents the damage of the system from hard-short condition and the soft-short condition from the over current of portable device.

Soft Start

The AP2965 implements the soft start function to reduce the inrush current during startup. The soft start begins once the input voltage raises above typical UVLO threshold of 4.5 V. The soft start time is typically 2 ms.

Thermal Shutdown

A thermal shutdown is implemented to prevent the damage due to excessive heat and power dissipation. Typically, the thermal shutdown happens at the junction temperature of 165 °C. When the thermal shutdown is triggered, the device stops switching until the junction temperature drops the hysteresis temperature lower than thermal shutdown threshold, then the device starts switching again.

Application Information

Design Requirement

Design Parameters	Target Values
Input Voltage Range	6 V to 40 V
Typical Input Voltage	24 V
Output Voltage	5 V
Output Current Rating	4.2 A
V_{CCOMP} at Full Load	320 mV

Table 1. Design Parameters

Setting the CC Limit

The simplified application circuit is showed on the front page. **Figure 2** shows the CC Limit at 5 V output verse R_S. According to this figure, R_S should be set at around 14 mΩ to output 4.2 A continuous current.

Setting the Cable Compensation Resistor

The cable compensation resistor, R_{CC}, determines the gain of the cable compensation. By subtitling V_{CCOMP}, I_{OUT}, R_S, V_{OS} and K into the Equation 1, R_{CC} = 25.09 kΩ. 24.9 kΩ is the closest standard value. **Table 2.** Shows the cable compensation voltage at different load with R_{CC} = 24.9 kΩ and R_S = 14 mΩ.

I_{LOAD} (A)	V_{CCOMP} (mV)
0	0
0.5	8
1	50
1.5	91
2	133
2.4	167
3	217
3.5	259
4	300
4.2	317

Table 2. Cable Compensation Voltage at Different Load

Setting the Output Voltage

The feedback resistors, R_1 and R_2, together with the cable compensation resistor, R_{CC}, program the output voltage at no load condition according to the Equation 2.

For QC 2.0 / 3.0 applications, the upper feedback resistor(R_{CC} + R_1) is fixed at 100 kΩ generally for compatibility. Thus, R_1 = 100 kΩ - 24.9 kΩ = 75.1 kΩ (75 kΩ is the closest standard value). By subtitling R_{CC}, R_1 and V_{OUT} into the Equation 2, R_2 = 24.975 kΩ (24.9 kΩ is the closest standard value).

Inductor Selection

Since the selection of the inductor affects the power supply's steady state operation, transient behavior, loop stability, and overall efficiency, the inductor is the most important component in switch power regulator design. Three most important specifications to the performance of the inductor are the inductor value, DC resistance, and saturation current.

The AP2965 designed to work with inductor values between 15 µH to 47 µH. A 15 µH inductor is typically available in a smaller or lower-profile package, while a 47 µH inductor produces lower inductor current ripple. If the output current is limited by the peak current limit of the IC, using a 47 µH inductor can maximize the converter's output current capability.

The tolerance of inductors can be ranging from 10 % to 30 %. The inductance will further decrease 20 % to 35 % from the value of zero bias current depending on the definition of saturation by inductor manufacturers. The basic requirements of selecting an inductor are the saturation current must be higher than the peak switching current and the DC rated current is higher than the average inductor current in normal operation. In buck converter, the average inductor current is equal to the output current. The inductor value can be derived from the Equation 3.

$$L = \frac{(V_{OUT} + V_{CCOMP}) \times (V_{IN} - V_{OUT} - V_{CCOMP})}{V_{IN} \times \Delta I_L \times F_{SW}} \qquad (3)$$

where

- ΔI_L is the inductor peak-to-peak ripple current.
- V_{OUT} is the output voltage at no load.
- V_{CCOMP} is the cable compensation voltage measured at the output
- V_{IN} is the input voltage.
- F_{SW} is the switching frequency

Lower inductor value results in higher ripple current and vice versa. Choose inductor ripple current approximately 25 % of the maximum load current, 4.2 A, or ΔI_L = 1.05 A. By subtitling V_{IN}(typ.), V_{OUT}, ΔI_L and F_{SW}(typ.) into the above equation, the inductor value, L, is 30 µH. The common inductor value is 33 µH.

The saturation current of the inductor must be higher than the maximum output current, 4.2 A, plus half of the inductor ripple current in worst case, i.e. highest operating V_{IN}(38 V) lowest F_{SW}(105kH), lowest inductor value(-10 ~ -30% from nominal value), to prevent the core from saturation. **Table 3** lists a typical toroid inductor specification that meet target application for the design requirement.

Core Manufacturer	Core Part Number	L(µH)	No. of Turns	Wire Ø (mm)	µ	AL (nH/N²)	Size[ODxIDxH] (mm)
KDM Magnetic Powder Cores	KS050-125A	33±10%	24	0.8	125	56	12.7x7.62x4.75

Table 3. Recommended Toroid Inductor

Input Capacitor Selection

The input capacitor reduces the surge current drawn from the input and switching noise from the device. The input capacitor impedance at the switching frequency should be less than the input source impedance to prevent high frequency switching current passing to the input. A low ESR input capacitor sized for maximum RMS current must be used. Multilayer Ceramic Capacitor(MLCC) with X5R or X7R dielectric is highly recommended because of their low ESR, low temperature coefficients and compact size characteristics. A 22 µF MLCC is sufficient for most of applications.

Output Capacitor Selection

The output capacitor is required to keep the output voltage ripple small and to ensure regulation loop stability. The output capacitor must have low impedance at the switching frequency. MLCC with X5R or X7R dielectric is recommended due to their low ESR and compact size characteristics. The output ripple, ΔV_{OUT}, is determined by:

$$\Delta V_{OUT} \leq \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times F_{SW} \times L} \times \left(ESR + \frac{1}{8 \times F_{SW} \times C_{OUT}} \right) \qquad (4)$$

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Layout Considerations

When doing the PCB layout, the following suggestions should be taken into consideration to ensure proper operation of the AP2965. These suggestions are also illustrated graphically in **Figure 3** and **Figure 4**.

1. The power path including the GND trace, the SW trace and the VIN trace should be as short as possible, direct and wide.

2. The FB pin should be connected directly to the center point of the output feedback resistors divider.

3. The resistor divider must be connected to the output capacitor and GND pin directly.

4. The input decoupling MLCC should be placed as close to the VIN and GND pins as possible and connected to input power plane and ground plane directly. This capacitor provides the AC current to the internal power MOSFET.

5. The power path between the output MLCC, C_5, and the power inductor should be kept short and the other terminal of the capacitor should connect to the ground plane directly to reduce noise emission.

6. Keep the switching node, SW, away from the sensitive FB node.

7. Keep the negative terminals of input capacitor and output capacitor as close as possible.

8. Use Kelvin sense connection techniques from the sensing resistor, Rs, pads directly to the CSP and CSN pins to achieve accurate CC limit.

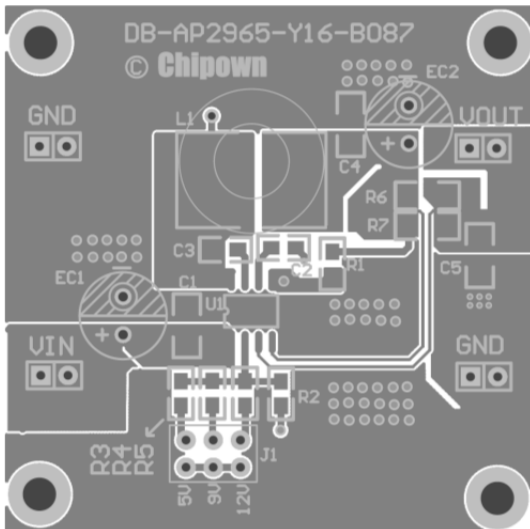9. Use large copper plane and thermal vias for GND for best heat dissipation and noise immunity.
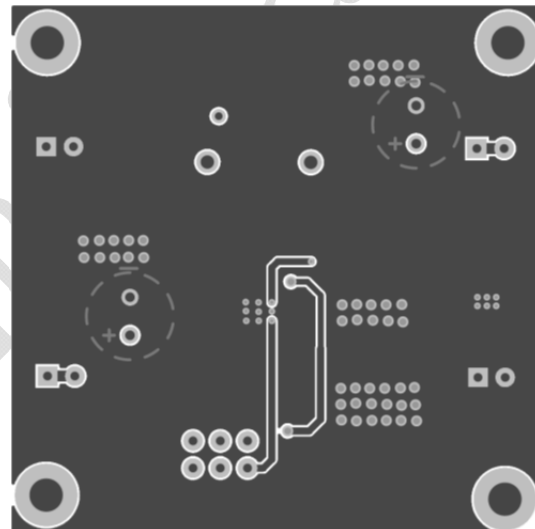

Figure 3. Top Layer

Figure 4. Bottom Layer

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Typical Performance Characteristics

All curves taken at V_{IN} = 12 V, V_{OUT} = 5 V with configuration in Typical Application Circuit with USB Interface IC shown in this datasheet. T_A = 25 °C, unless otherwise specified.

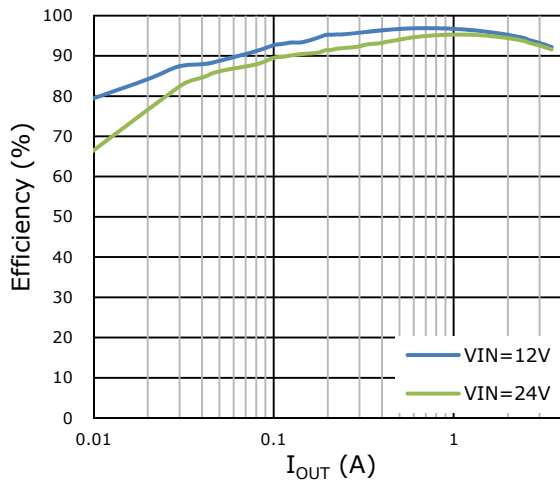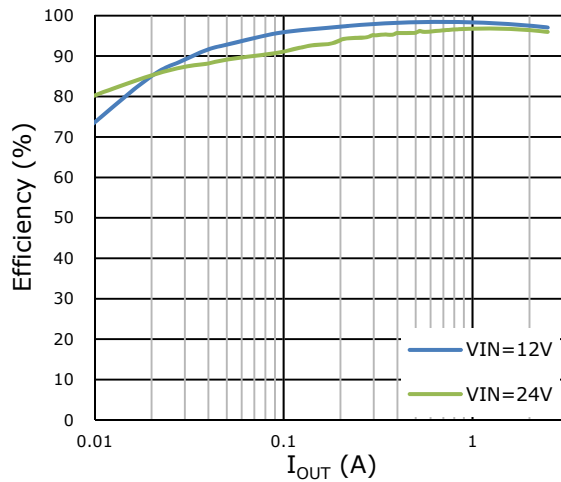**Figure 5. Efficiency vs. Load Current, V_{OUT} = 5 V**

Figure 6. Efficiency vs. Load Current, V_{OUT} = 9 V
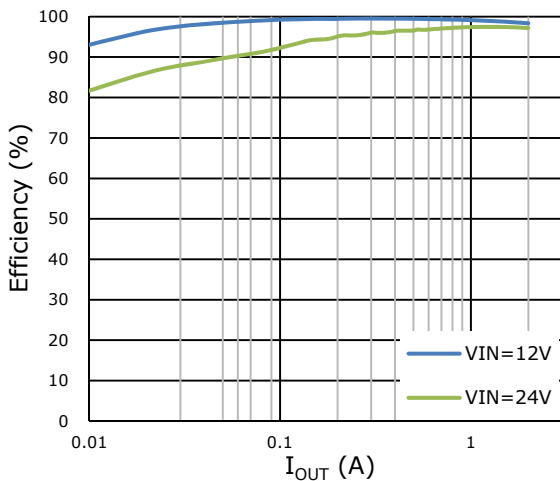

Figure 7. Efficiency vs. Load Current, V_{OUT} = 12 V

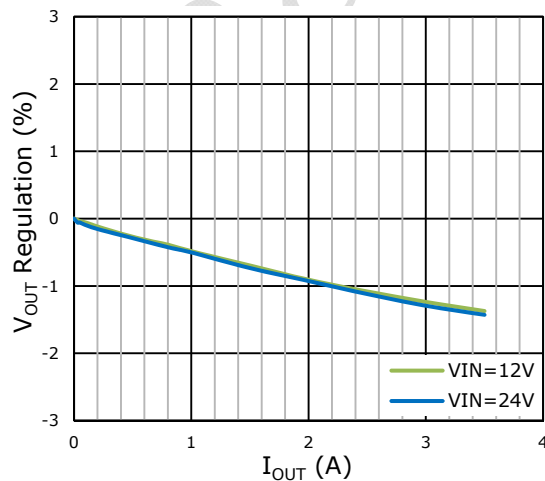**Figure 8. V_{OUT} Regulation vs. Load Current, R_{CC} = 0, R_1 = 100 kΩ**
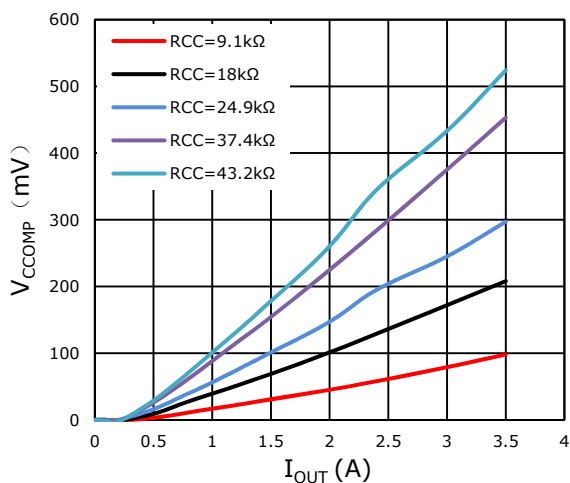
Figure 9. Cable Compensation Voltage vs. Load Current, R_S = 15mΩ

Typical Performance Characteristics (continued)

All curves taken at V_{IN} = 12 V, V_{OUT} = 5 V with configuration in Typical Application Circuit with USB Interface IC shown in this datasheet. T_A = 25 °C, unless otherwise specified.
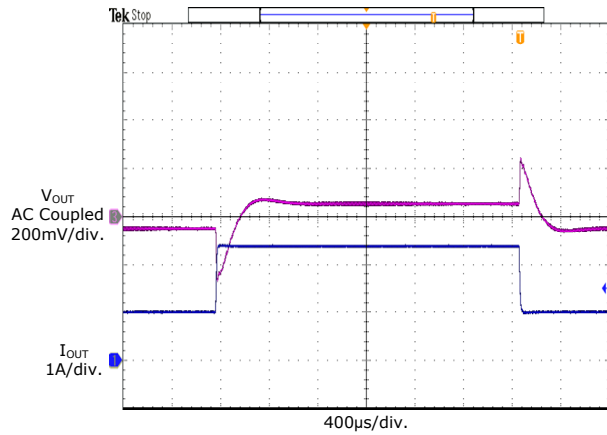
Figure 18. Load Transient

Figure 19. Load Transient

*The purpose of this Preliminary Information is to confirm features and specifications. It does not imply a product under development or any commitment to do so. All features, part number and specification are subject to change.

Package Information
Package Outline and Dimensions

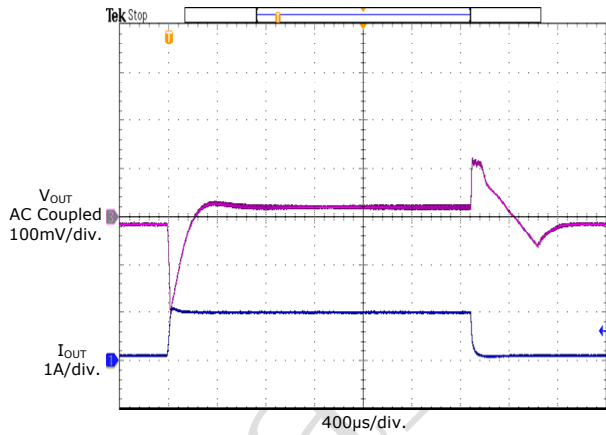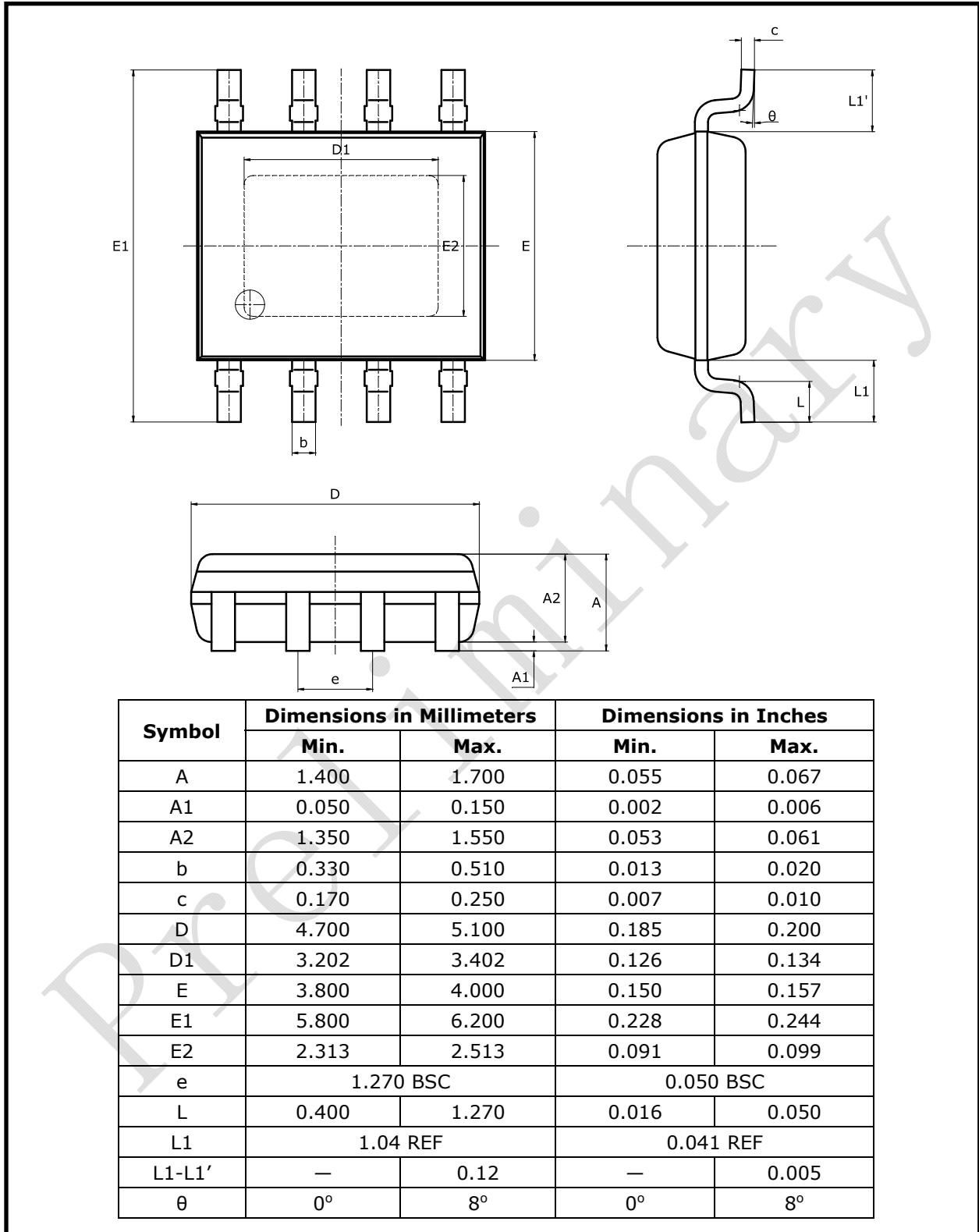| Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min.	Max.	Min.	Max.
A	1.400	1.700	0.055	0.067
A1	0.050	0.150	0.002	0.006
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.200
D1	3.202	3.402	0.126	0.134
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
E2	2.313	2.513	0.091	0.099
e	1.270 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
L1	1.04 REF		0.041 REF	
L1-L1'	—	0.12	—	0.005
θ	0°	8°	0°	8°

Notes:
1. This drawing is subjected to change without notice.
2. Body dimensions do not include mold flash or protrusion.
3. This package conforms to JEDEC MS-012, variation BA.

*The purpose of this Preliminary Information is to confirm features and specifications. It does not imply a product under development or any commitment to do so. All features, part number and specification are subject to change.

Tape and Reel Information

A (mm)	T (mm)	T1 (mm)	H (mm)	ØC (mm)	ØD (mm)	d (mm)	A0 (mm)	B0 (mm)	K0 (mm)
328	1.8	13	80	13.5	21.6	2.5	6.7	5.4	2.1
W (mm)	F (mm)	E1 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	ØD0 (mm)	ØD1 (mm)	Pin 1 Quadrant	
12	5.5	1.75	4	8	2	1.5	1.5		
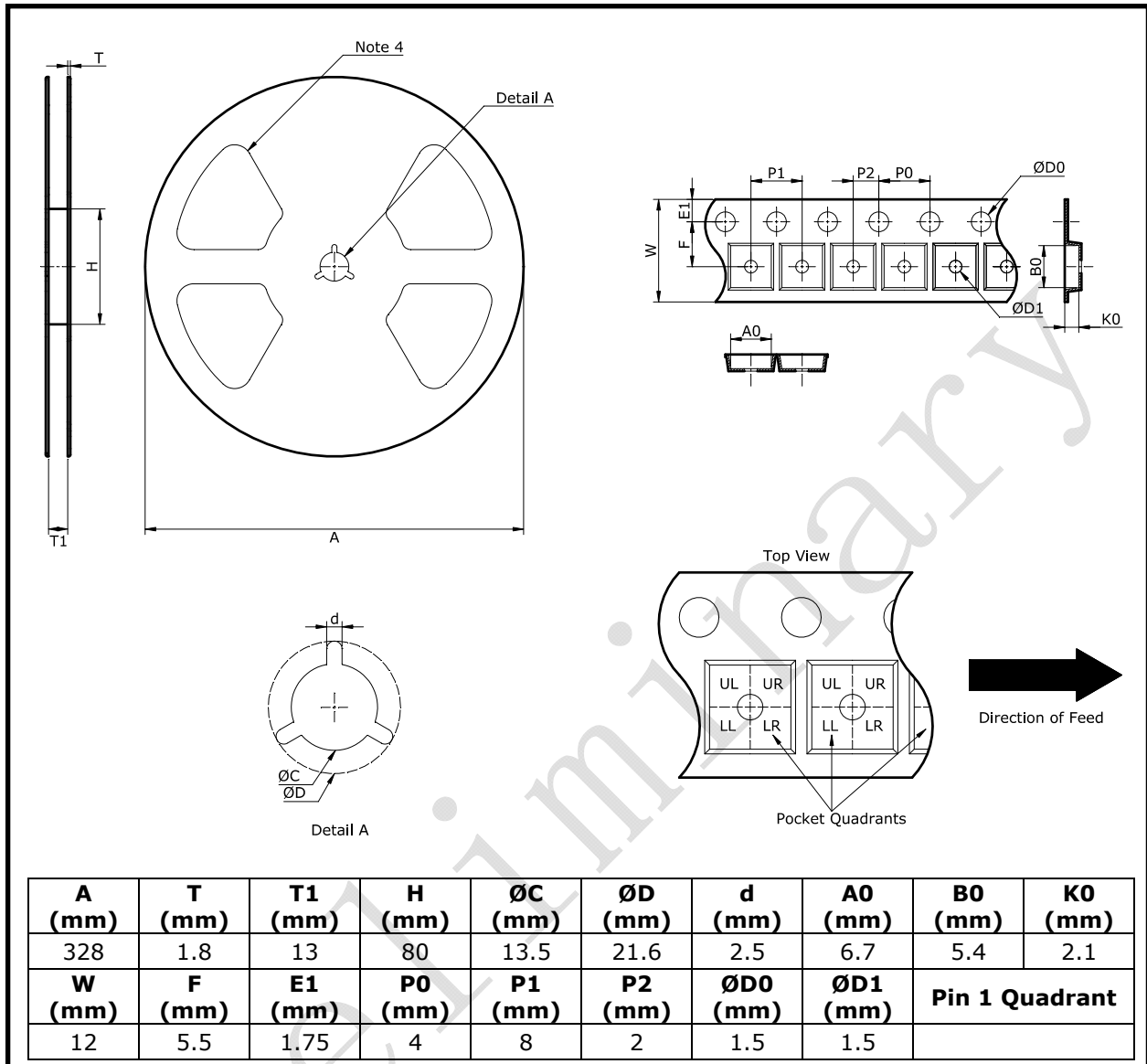
Notes:
1. This drawing is subjected to change without notice.
2. All dimensions are nominal and in mm.
3. This drawing is not in scale and for reference only. Customer can contact Chipown sales representative for further details.
4. The number of flange openings depends on the reel size and assembly site. This drawing shows an example only.