APW7004

ANPEC

Synchronous-Rectifier PWM Controller for Pentium™ II Microprocessor

Features

- Simple Single-Loop Control Design-Voltage-Mode PWM Control
- Fast Transient Response
  - High-Bandwidth Error Amplifier
- 5-Bit Digital-to-Analog Output Voltage Selection
  - Wide Range from $1.3V_{DC}$ to $3.5V_{DC}$
  - 0.1V Binary Steps from $2.1V_{DC}$ to $3.5V_{DC}$
  .05V Binary Steps from $1.3V_{DC}$ to $2.05 V_{DC}$
- VID0-4 Input Pins with Pull High Resistors Built in
- Power-Good Output Voltage Monitor, PGOOD Pin with an Open Collector Configuration
- Over-Voltage and Over-Current Fault Monitors
  - Uses MOSFET's $R_{DS(ON)}$ as Current Sensing, No Extra Element Required
- Programmable Switching Frequency Setting
  - 200kHz Free-Running Oscillator

Applications

- Power Supply for Pentium™, Pentium Pro™, Pentium™ II, PowerPC™, K6™ , 6´86™ and Alpha™ Microprocessors
- High-Power 5V to 3.xV (or below) DC-DC Regulators
- Low-Voltage Distributed Power Supplies

6´ 86™ is a trademark of Cyrix Corporation
Alpha™ is a trademark of Digital Equipment Corporation
K6™ is a trademark of Advanced Micro Devices, Inc.
Pentium™ is a trademark of Intel Corporation
PowerPC™ is a trademark of IBM

General Description

The APW7004 provides a complete control and multiple protection for a DC-DC converter optimized for high performance microprocessor applications. It is designed to drive two N-Channel MOSFETs in a synchronous-rectified buck topology. The APW7004 integrates output voltage control, output voltage programming, monitoring and protection functions into a single chip IC.
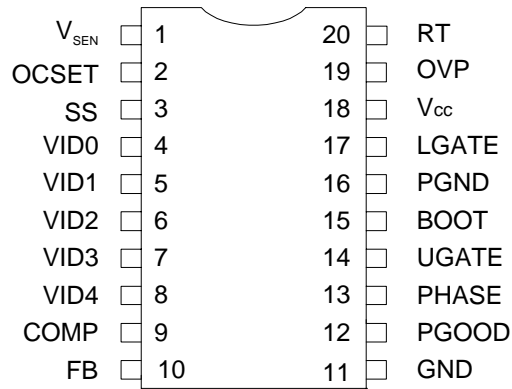
The APW7004 includes a 5-bit digital-to-analog converter (DAC) that provides a easily adjustable and precisely output voltage from $2.1V_{DC}$ to $3.5V_{DC}$ in 0.1 increments and from 1.3 V_{DC} to 2.05 V_{DC} in 0.05V increments. Any selected output voltage can be maintained within ±1% accuracy over temperature and line voltage variations.

With a 200kHz free-running triangle-wave oscillator and a error amplifier featuring a 15MHz unity-gain bandwidth and 6V/us slew rate inside the chip, APW7004 can implement a simple, single feedback loop, voltage-mode control topology with high transient performance.
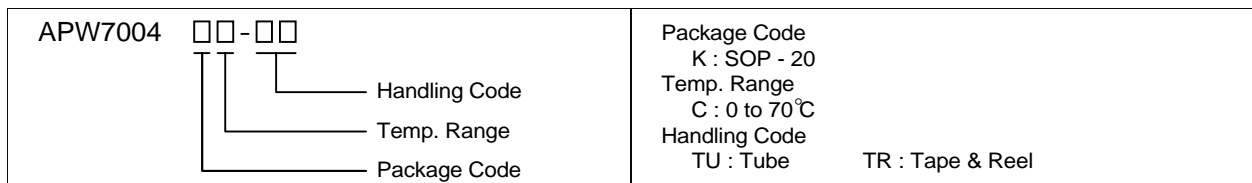
The APW7004 also features with multiple protections against over-current and over-voltage conditions by inhibiting PWM operation. The APW7004 uses the $R_{DS(ON)}$ of the upper MOSFET as the current sensing element which eliminates the demend for an extra component. The APW7004 also monitors the output voltage using a comparator with hysteresis that tracks the DAC output and issues a Power Good signal once the output is within ±10%.

Pin Description

```
           V_SEN  ☐ 1        20 ☐  RT
          OCSET   ☐ 2        19 ☐  OVP
             SS   ☐ 3        18 ☐  Vcc
           VID0   ☐ 4        17 ☐  LGATE
           VID1   ☐ 5        16 ☐  PGND
           VID2   ☐ 6        15 ☐  BOOT
           VID3   ☐ 7        14 ☐  UGATE
           VID4   ☐ 8        13 ☐  PHASE
           COMP   ☐ 9        12 ☐  PGOOD
             FB    ☐ 10      11 ☐  GND
```

Ordering Information

APW7004 ☐☐-☐☐	Package Code
— Handling Code	K : SOP - 20
— Temp. Range	Temp. Range
— Package Code	C : 0 to 70℃
	Handling Code
	TU : Tube TR : Tape & Reel

Block Diagram
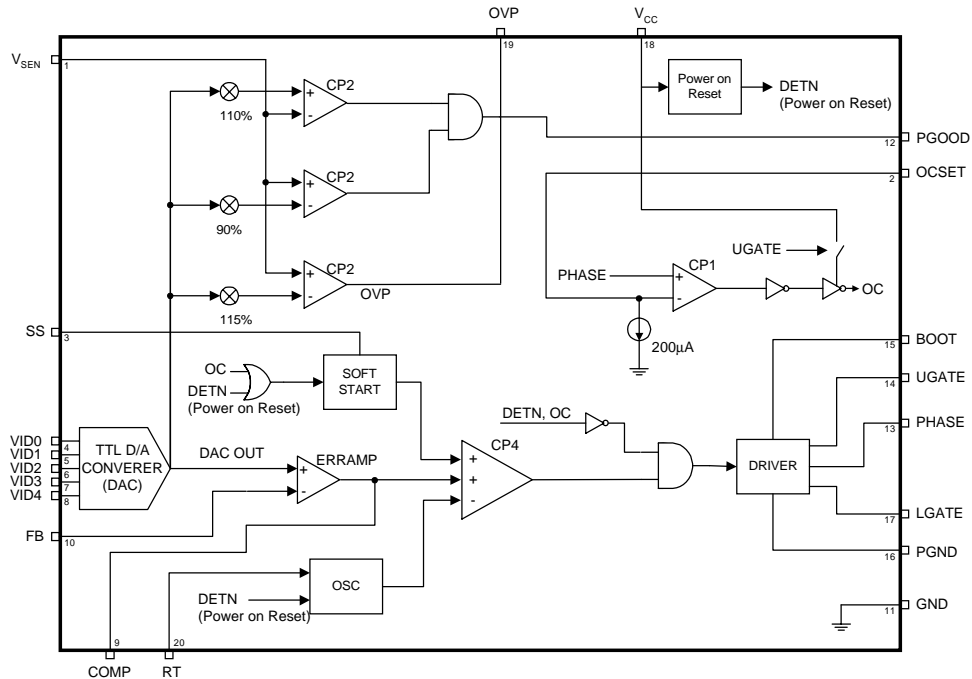
Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
V_{CC}	Supply Voltage	15	V
$V_{BOOT} - V_{PHASE}$	Boot Voltage	15	V
V_I, V_O	Input , Output or I/O Voltage	GND - 0.3 V to V_{CC} + 0.3	V
T_A	Operating Ambient Temperature Range	0 to 70	°C
T_J	Junction Temperature Range	0 to 150	°C
T_{STG}	Storage Temperature Range	-65 to +150	°C
T_S	Soldering Temperature	300,10 seconds	°C

Thermal Characteristics

Symbol	Parameter	Value	Unit
$R_{\theta JA}$	Thermal Resistance in Free Air		°C/W
	SOP	110	
	SOP (with 3in^2 of Copper)	86	

Electrical Characteristics

Recommended operating conditions , unless otherwise noted

Symbol	Parameter	Test Conditions	APW7004 Min.	APW7004 Typ.	APW7004 Max.	Unit
V_{CC} Supply Current						
I_{CC}	Nominal Supply	UGATE and LGATE open		3		mA
Power-on Reset						
	Rising V_{CC} Threshold	Vocset=4.5V		9.0		V
	Falling V_{CC} Threshold	Vocset=4.5V		8.8		V
Oscillator						
	Free Running Frequency	RT= Open	185	200	215	kHz
ΔV_{OSC}	Ramp Amplitude	RT= Open		2		V_{P-P}
Reference and DAC						
	DAC(VID0-VID4) Input Low Voltage				0.8	V
	DAC(VID0-VID4) Input High Voltage			3.0		V
	DACOUT Voltage accuracy		-1.0		+1.0	%
Error Amplifier						
	DC Gain			88		dB
GBW	Gain-Bandwidth Product			15		MHz
SR	Slew Rate	COMP=20pF		6		V/µs

Electrical Characteristics CONT.

Symbol	Parameter	Test Conditions	APW7004			Unit
			Min.	Typ.	Max.	
Gate Drivers						
$R_{UG, SOURCE}$	Upper Gate Source	V_{BOOT}-V_{PHASE}=12V		8.3		Ω
$R_{UG, SINK}$	Upper Gate Sink	V_{BOOT}-V_{PHASE}=12V		5		Ω
$R_{LG, SOURCE}$	Lower Gate Source	V_{CC}=12V		8.3		Ω
$R_{LG, SINK}$	Lower Gate Sink	V_{CC}=12V		5		Ω
Protection						
	Over-Voltage Trip (V_{SEN}/DACOUT)			115	120	%
I_{OCSET}	OCSET Current Source	V_{OCSET}=4.5V_{DC}	170	200	230	μA
I_{OVP}	OVP Souring Current	V_{SEN}=5.5V ,V_{OVP}=0V		30		mA
I_{SS}	Soft Start Current			10		μA
Power Good						
	Upper Threshold (V_{SEN}/DACOUT)	V_{SEN} Rising		110		%
	Lower Threshold (V_{SEN}/DACOUT)	V_{SEN} Rising		90		%
	Hysteresis (V_{SEN}/DACOUT)	Upper and Lower Threshold		2		%
V_{PGOOD}	PGOOD Voltage Low	I_{PGOOD}= -5mA		0.5		V

Pin Function Description

VSEN (pin 1)

Connect this pin to the converter's voltage output. The PGOOD and OVP comparator circuits monitor output voltage status and act over voltage protection by using this signal.

OCSET(pin 2)

Connect a resistor(R_{OCSET}) from this pin to the drain of the upper MOSFET. An internal 200mA current source (I_{OCS}), R_{OCSET}, and the upper MOSFET's on-resistance ($R_{DS(ON)}$) set the converter over-current (OC) trip point according to the following equation:
I_{PEAK}= I_{OCS}´ R_{OCSET}/$R_{DS(ON)}$
An over-current trip resets the soft-start function.

SS (Pin 3)

Connect a capacitor from this pin to ground. This capacitor, along with an internal 10mA current source, sets the soft-start interval of the converter.

VID0-4 (Pins 4-8)

VID0-4 are the input pins to the 5-bit DAC. The states of these five pins decide the internal voltage reference (DACOUT). The level of DACOUT sets the converter output voltage and also sets the PGOOD and OVP thresholds. Table 1 specifies DACOUT for the 32 combinations of DAC inputs.

COMP (pin 9) and FB (pin 10)
COMP and FB are the accessible pins of the error amplifier. FB pin is the inverting input of the error amplifier and COMP pin is output of the error amplifier. These pins provide the compensation for the voltage-control feedback loop of the converter.

GND (Pin 11)
GND is signal ground of the IC. All voltage levels are measured with respect to this pin.

Electrical Characteristics Cont.

PGOOD (Plin 12)

PGOOD is an open collector output used to indicate the status of the converter output voltage. This pin is pulled low when the converter output is not within ±10% of the DACOUT reference voltage. The PGOOD pin is floating when no CPU exists.

PHASE (pin 13)

Connect the PHASE pin to the source of the upper MOSFET. This pin is used to monitor the voltage drop across the upper MOSFET for over-current protection.

UGATE (pin 14)

Connect UGATE to the upper MOSFET gate. This pin enables the gate drive signal to drive the upper MOSFET .

BOOT (pin 15)

BOOT pin provides bias voltage to the upper MOSFET gate driver. A bootstrap circuit could be used to pump a BOOT voltage for enforcing the driving capability of the gate driver and improving the performance of the upper MOSFET.

PGND(pin 16)

PGND pin provides the power ground connection. Connect this pin to the source of the lower MOSFET.

LGATE (pin 17)

Connect LGATE to the lower MOSFET gate. This pin enables the gate drive signal to drive the lower MOSFET.

V_{CC} (pin 18)

Connect V_{CC} to 12V voltage supply. This pin supplies the bias for the chip.

OVP (pin 19)

OVP pin reports the event of an over-voltage condition . Converter output rising 15% more than the DAC-set voltage triggers a high output on this pin with a typical 30mA sourcing capability which can be used to drive an external device and disables PWM gate drive circuitry.

RT (pin 20)

RT pin provides oscillator switching frequency adujstment. By connecting a resistor (R_T) from this pin to GND, the nominal 200kHz switching frequency is increased. Conversely. connecting a pull-up resistor (R_T) from this pin to V_{CC} reduces the switching frequency.

Table 1 Output Voltage Program

Pin Name					Nominal Output Voltage Dacout	Pin Name					Nominal Output Voltage Dacout
VID4	VID3	VID2	VID1	VID0		VID4	VID3	VID2	VID1	VID0	
0	1	1	1	1	1.3	1	1	1	1	1	0
0	1	1	1	0	1.35	1	1	1	1	0	2.1
0	1	1	0	1	1.4	1	1	1	0	1	2.2
0	1	1	0	0	1.45	1	1	1	0	0	2.3
0	1	0	1	1	1.5	1	1	0	1	1	2.4
0	1	0	1	0	1.55	1	1	0	1	0	2.5
0	1	0	0	1	1.6	1	1	0	0	1	2.6
0	1	0	0	0	1.65	1	1	0	0	0	2.7
0	0	1	1	1	1.7	1	0	1	1	1	2.8
0	0	1	1	0	1.75	1	0	1	1	0	2.9
0	0	1	0	1	1.8	1	0	1	0	1	3.0
0	0	1	0	0	1.85	1	0	1	0	0	3.1
0	0	0	1	1	1.90	1	0	0	1	1	3.2
0	0	0	1	0	1.95	1	0	0	1	0	3.3
0	0	0	0	1	2.00	1	0	0	0	1	3.4
0	0	0	0	0	2.05	1	0	0	0	0	3.5

Application Schematic
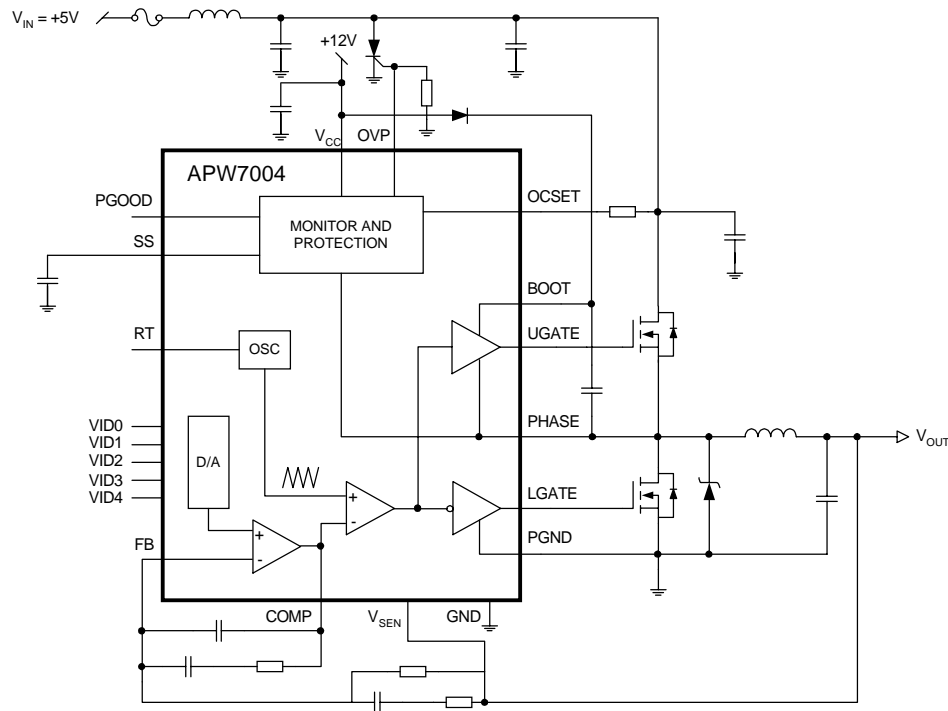
Packaging Information

SO – 300mil (Reference JEDEC Registration MS-013)
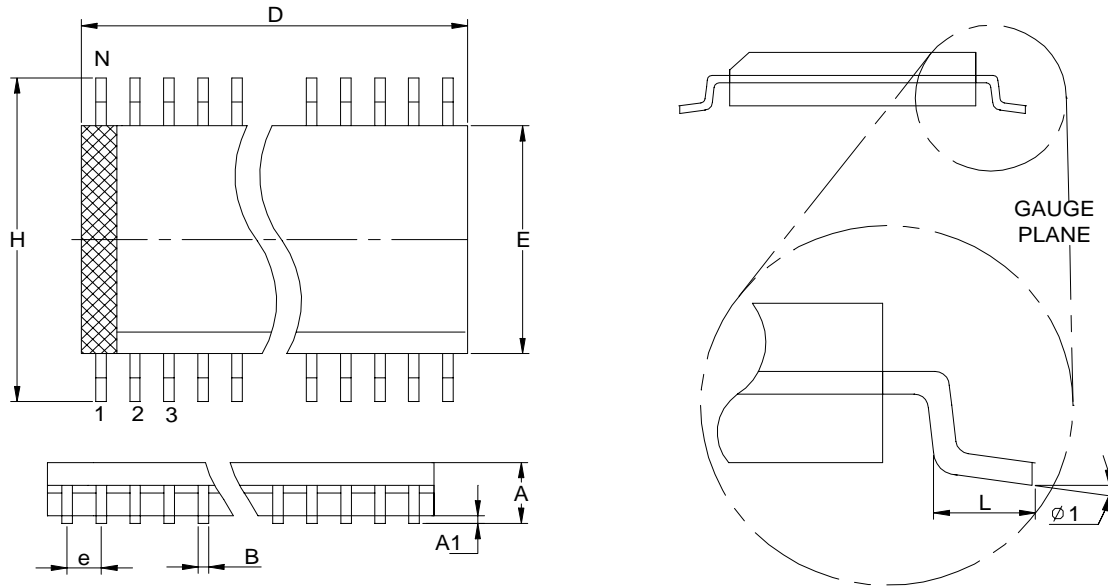
Dim	Millimeters		Variations- D			Dim	Inches		Variations- D		
	Min.	**Max.**	**Variations**	**Min.**	**Max.**		**Min.**	**Max.**	**Variations**	**Min.**	**Max.**
A	2.35	2.65	SO-16	10.10	10.50	A	0.093	0.1043	SO-16	0.398	0.413
A1	0.10	0.30	SO-18	11.35	11.76	A1	0.004	0.0120	SO-18	0.447	0.463
B	0.33	0.51	SO-20	12.60	13	B	0.013	0.020	SO-20	0.496	0.512
D	See variations		SO-24	15.20	15.60	D	See variations		SO-24	0.599	0.614
E	7.40	7.60	SO-28	17.70	18.11	E	0.2914	0.2992	SO-28	0.697	0.713
e	1.27BSC		SO-14	8.80	9.20	e	0.050BSC		SO-14	0.347	0.362
H	10	10.65				H	0.394	0.419			
L	0.40	1.27				L	0.016	0.050			
N	See variations					N	See variations				
φ 1	0°	8°				φ 1	0°	8°			

Physical Specifications

Terminal Material	Solder-Plated Copper (Solder Material : 90/10 or 63/37 SnPb)
Lead Solderability	Meets EIA Specification RSI86-91, ANSI/J-STD-002 Category 3.
Packaging	1000 devices per reel

Reflow Condition (IR/Convection or VPR Reflow)

Reference JEDEC Standard J-STD-020A APRIL 1999
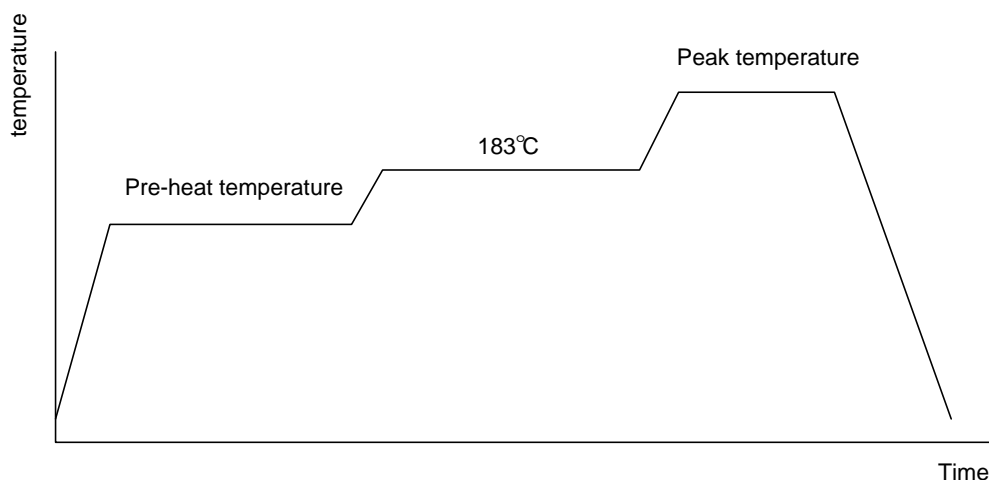
Classification Reflow Profiles

|	Convection or IR/Convection	VPR
Average ramp-up rate(183°C to Peak)	3°C/second max.	10 °C /second max.
Preheat temperature 125 ± 25°C)	120 seconds max	
Temperature maintained above 183°C	60 – 150 seconds	
Time within 5°C of actual peak temperature	10 –20 seconds	60 seconds
Peak temperature range	220 +5/-0°C or 235 +5/-0°C	215-219°C or 235 +5/-0°C
Ramp-down rate	6 °C /second max.	10 °C /second max.
Time 25°C to peak temperature	6 minutes max.	

Package Reflow Conditions

pkg. thickness ≥ 2.5mm and all bgas	pkg. thickness < 2.5mm and pkg. volume ≥ 350 mm³	pkg. thickness < 2.5mm and pkg. volume < 350mm³
Convection 220 +5/-0 °C		Convection 235 +5/-0 °C
VPR 215-219 °C		VPR 235 +5/-0 °C
IR/Convection 220 +5/-0 °C		IR/Convection 235 +5/-0 °C

Reliability test program

Test item	Method	Description
SOLDERABILITY	MIL-STD-883D-2003	245°C , 5 SEC
HOLT	MIL-STD-883D-1005.7	1000 Hrs Bias @ 125 °C
PCT	JESD-22-B, A102	168 Hrs, 100 % RH , 121°C
TST	MIL-STD-883D-1011.9	-65°C ~ 150°C, 200 Cycles
ESD	MIL-STD-883D-3015.7	VHBM > 2KV, VMM > 200V
Latch-Up	JESD 78	10ms , I_{tr} > 100mA

Carrier Tape & Reel Dimensions
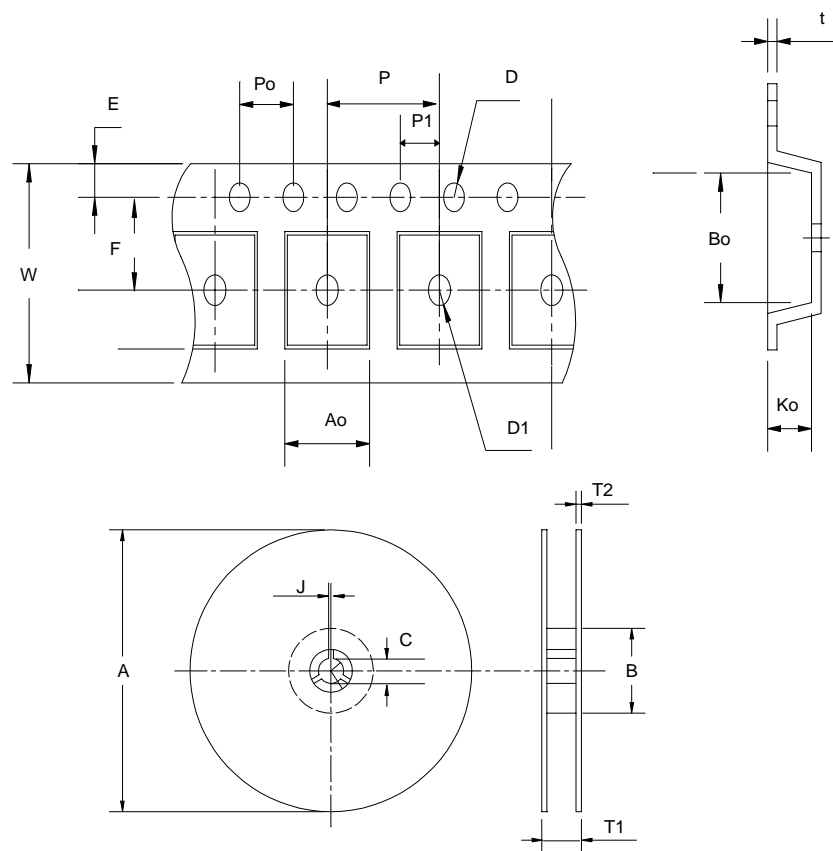
Application	A	B	C	J	T1	T2	W	P	E
SOP-20	330±1	62 ± 1.5	12.75 ±0.15	2 + 0.6	24.4 +0.2	2± 0.2	24 + 0.3 - 0.1	12± 0.1	1.75± 0.1

Application	F	D	D1	Po	P1	Ao	Bo	Ko	t
SOP-20	11.5 ± 0.1	1.5+0.1	1.5+0.25	4.0 ± 0.1	2.0 ± 0.1	8.2 ± 0.1	13± 0.1	2.5± 0.1	0.35±0.013

(mm)

Cover Tape Dimensions

Carrier Width	24
Cover Tape Width	21.3

(mm)

Customer Service

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