Dual Channel 300mA Low Dropout Linear Regulator

Features

- **Dual Regulator Outputs**
- **Low Dropout Voltage: Typical 200mV at 300mA**
- **Wide Input Voltage Range: 2V to 5.5V**
- **Low Quiescent Current: Typical 58μA**
- **High PSRR: 70dB at 1kHz**
- **Low Shutdown Current: <1μA**
- **Shutdown Function**
- **Output Current-Limit Protection**
- **Short-Circuit Current-Limit Protection**
- **Over-Temperature Protection**
- **Lead Free and Green Devices Available (RoHS Compliant)**

Applications

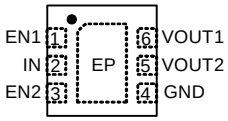
- **Mobile Phone**
- **GPS Navigation**
- **Blue Tooth Headset**

General Description

The APL5535R is a dual channel low dropout linear regulator, which operates from 2V to 5.5V input voltage and delivers up to 300mA output current at each channel. Typical dropout voltage is only 200mV at 300mA.

The APL5535R with low quiescent current, high PSRR, and low noise is ideal for battery powered system appliances. Other features include logic-controlled shut-down mode, over-temperature protection, short-circuit current-limit, and current-limit protection to ensure specified output current. The APL5535R is available in the TDFN 1.6x1.6-6 package.

Pin Configurations



TDFN1.6x1.6-6
(Top View)

Ordering and Marking Information

APL5535R □□□□□-□□□

- Assembly Material
- Handling Code
- Temperature Range
- Package Code
- Voltage Code

Voltage Code
See Voltage Code Table
Package Code
QB : TDFN1.6x1.6-6
Operating Ambient Temperature Range
I : -40 to 85°C
Handling Code
TR : Tape & Reel
Assembly Material
G : Halogen and Lead Free Device

APL5535R-VVQB: 5VV / X

VV - Voltage Code
X - Date Code

Note : ANPEC lead-free products contain molding compounds/die attach materials and 100% matte tin plate termination finish; which are fully compliant with RoHS. ANPEC lead-free products meet or exceed the lead-free requirements of IPC/JEDEC J-STD-020D for MSL classification at lead-free peak reflow temperature. ANPEC defines "Green" to mean lead-free (RoHS compliant)and halogen free (Br or Cl does not exceed 900ppm by weight in homogeneous material and total of Br and Cl does not exceed 1500ppm by weight).

ANPEC reserves the right to make changes to improve reliability or manufacturability without notice, and advise customers to obtain the latest version of relevant information to verify before placing orders.

Voltage Code Table

Output Voltage		Voltage Code	Output Voltage		Voltage Code
V_{OUT1} (V)	V_{OUT2} (V)		V_{OUT1} (V)	V_{OUT2} (V)	
1.30	2.80	7M	1.20	2.80	5M
1.85	1.85	bb	1.85	1.50	b9
1.50	1.50	99	1.50	2.80	9M
1.80	1.20	C5	1.80	2.60	CK
2.50	1.80	JC	1.80	3.30	CR
2.50	3.00	JO	2.50	2.80	JM
2.80	2.85	Ud	2.50	3.30	JR
2.85	2.85	dd	2.85	1.85	db
2.80	1.80	MC	2.85	1.80	dC
2.80	3.30	MR	2.80	2.80	MM
2.80	3.00	MO	3.00	1.80	OC
3.30	2.85	Rd	3.00	3.00	OO
3.30	3.30	RR	3.30	3.00	RO
3.15	2.80	eM	3.30	3.10	RP

Available Voltage Version

Code	5	7	9	A	C	b	D	E	F	J	K
Voltage	1.20	1.30	1.50	1.60	1.80	1.85	1.90	2.00	2.10	2.50	2.60
Code	c	L	M	d	N	O	P	e	Q	R	
Voltage	2.65	2.70	2.80	2.85	2.90	3.00	3.10	3.15	3.20	3.30	

Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Rating	Unit
V_{IN}	VIN Input Voltage (VIN to GND)	-0.3 ~ 7	V
V_{EN1}, V_{EN2}	EN1, EN2 to GND Voltage	-0.3 ~ 7	V
T_J	Maximum Junction Temperature	150	°C
T_{STG}	Storage Temperature	-65 ~ 150	°C
T_{SDR}	Maximum Lead Soldering Temperature, 10 Seconds	260	°C

Note1: 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 under "recommended operating conditions" is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Thermal Characteristics

Symbol	Parameter	Typical Value	Unit
θ_{JA}	Junction-to-Ambient Resistance in Free Air (Note 2) TDFN1.6x1.6-6	165	°C/W

Note 2: θ_{JA} is measured with the component mounted on a high effective thermal conductivity test board in free air.

Recommended Operating Conditions (Note 3)

Symbol	Parameter	Range	Unit
V_{IN}	VIN Input Voltage (VIN to GND)	2 ~ 5.5	V
V_{EN1}, V_{EN2}	EN1, EN2 to GND Voltage	0 ~ 5.5	V
I_{OUT}	VOUT Output Current	0 ~ 300	mA
T_A	Ambient Temperature	-40 ~ 85	°C
T_J	Junction Temperature	-40 ~ 125	°C

Note 3: Refer to the typical application circuit

Electrical Characteristics

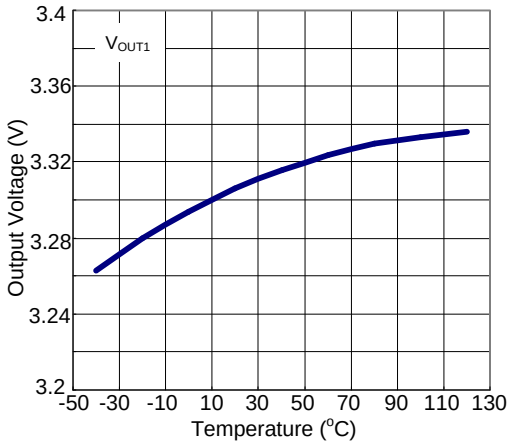
Unless otherwise specified, these specifications apply over V_{IN}=V_{OUT}+1V, V_{EN1}= V_{EN2}=5V and T_A= -40 to 85 °C. Typical values are at T_A=25°C.

Symbol	Parameter	Test Conditions		APL5535R			Unit
				Min.	Typ.	Max.	
UNDER-VOLTAGE LOCKOUT (UVLO) AND SUPPLY CURRENT							
	VIN UVLO Threshold Voltage	V_{IN} rising, T_A= -40 to 85 °C		-	1.8	-	V
	VIN UVLO Hysteresis			-	0.1	-	V
I_Q	VIN Supply Current	No load, V_{EN1}= V_{EN2}=5V		-	58	90	µA
		No load, V_{EN1}= V_{EN2}=0V		-	-	1	µA
OUTPUT VOLTAGE (REGULATOR1 AND REGULATOR2)							
	Output Voltage Accuracy	I_{OUT}=1mA to 300mA, T_A= -40 °C to 85 °C		-3.5	-	+3.5	%
	Line Regulation	I_{OUT}=1mA, V_{IN}=V_{OUT}+0.3V to 5.5V, or V_{IN}=2.5V to 5.5V		-	-	0.2	%/V
	Load Regulation	I_{OUT}=1mA to 300mA		-	-	1	%
V_{DROP}	Dropout Voltage(Note 4)	I_{OUT}=300mA		-	240	330	mV
PSRR	Power Supply Rejection Ratio	I_{OUT}=50mA, C_{OUT}=2.2µF	f=100Hz	-	70	-	dB
			f=1kHz	-	70	-	
			f=10kHz	-	60	-	
			f=100kHz	-	35	-	
	Output Noise	I_{OUT}=1mA, BW=10 to 100kHz, C_{OUT}=10µF		-	100	-	μV_{RMS}
	VOUT Discharge Resistance	V_{EN1}= V_{EN2}=0V		-	0.7	-	kΩ
ENABLE/DISABLE (EN1 AND EN2)							
V_{IH}	EN Input Logic HIGH	V_{IN}=2.5V to 5.5V		1.5	-	-	V
V_{IL}	EN Input Logic LOW	V_{IN}=2.5V to 5.5V		-	-	0.4	V
	EN Input Current	V_{EN1}= V_{EN2}=5V		-	0.2	-	µA
PROTECTIONS (REGULATOR1 AND REGULATOR2)							
I_{LIMIT}	Current Limit Threshold			330	450	750	mA
I_{SHORT}	Short-Circuit Output Current			-	50	-	mA
	Over-Temperature Threshold			-	160	-	°C
	Over-Temperature Hysteresis			-	40	-	°C
	Soft-Start Time			-	60	-	µs

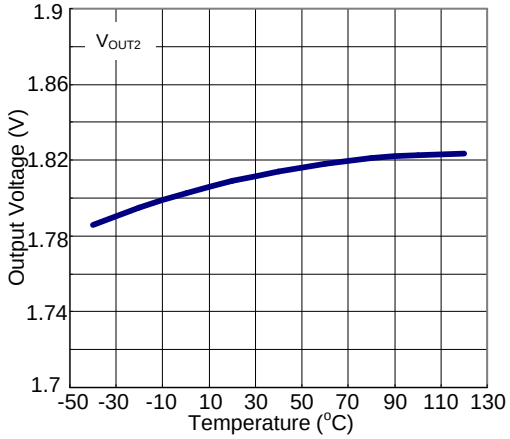
Note 4: The dropout voltage is defined as V_{IN} - V_{OUT}, when V_{OUT} is 100mV below the value of V_{OUT} for V_{IN} = V_{OUT} + 1V.

Typical Operating Characteristics

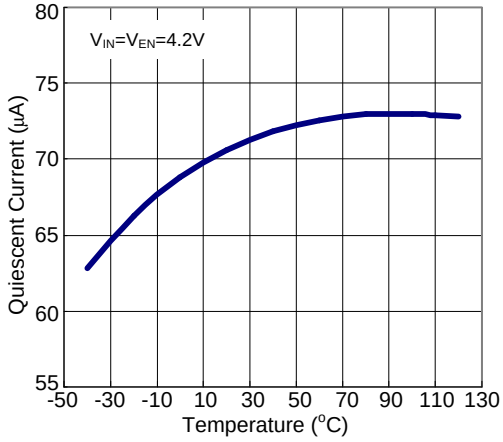
Output Voltage vs. Temperature



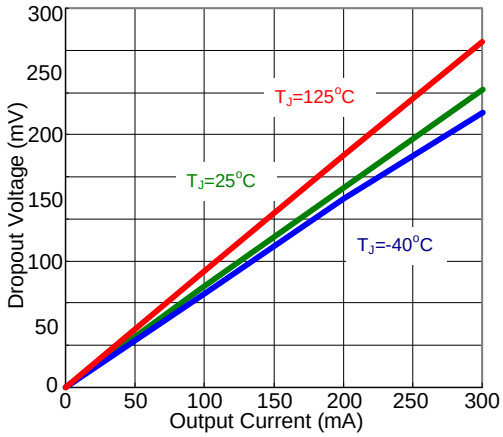
Output Voltage vs. Temperature



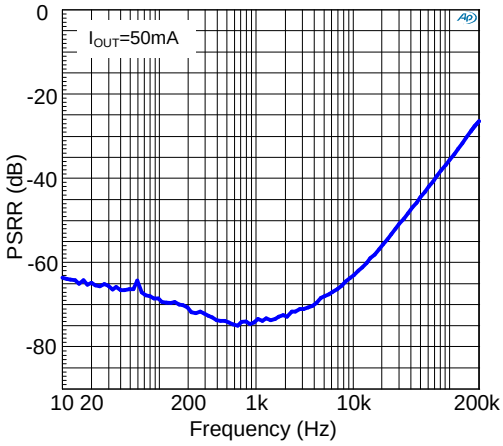
Quiescent Current vs. Temperature



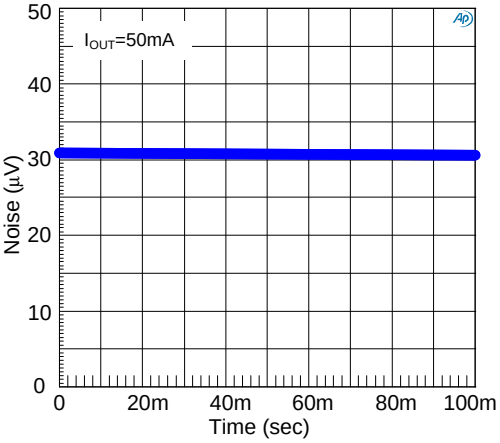
Dropout Voltage vs. Output Current



PSRR vs. Frequency

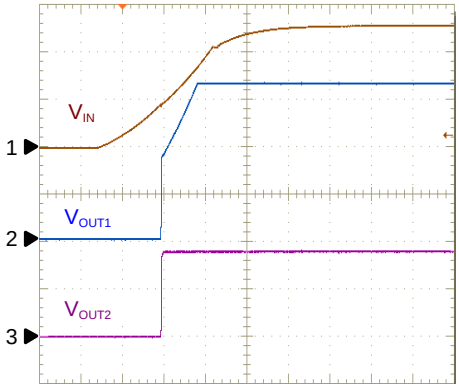


Noise



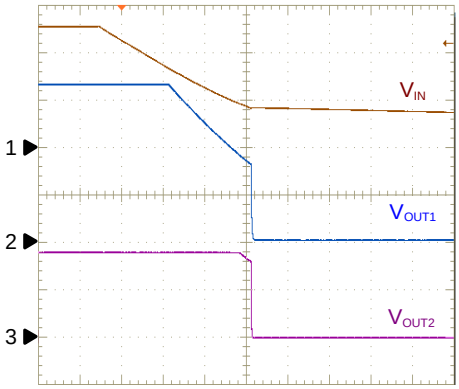
Operating Waveforms

Power on



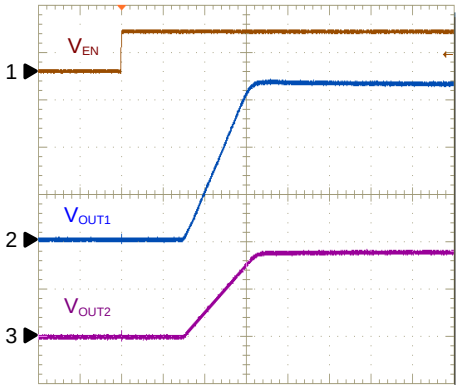
C_{IN}=1µF,C_{OUT}=1µF
I_{OUT1}=I_{OUT2}=10mA
CH1:V_{IN},2V/Div, DC
CH2:V_{OUT1},1V/Div, DC
CH3:V_{OUT2},1V/Div, DC
TIME:4ms/Div

Power off



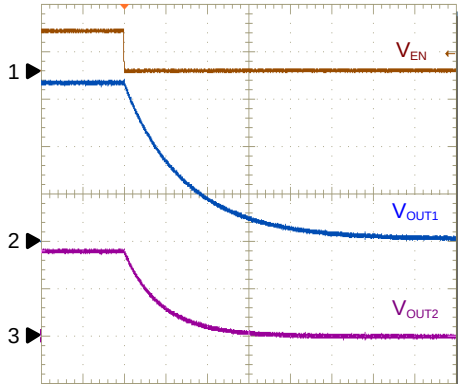
C_{IN}=1µF,C_{OUT}=1µF
I_{OUT1}=I_{OUT2}=10mA
CH1:V_{IN},2V/Div, DC
CH2:V_{OUT1},1V/Div, DC
CH3:V_{OUT2},1V/Div, DC
TIME:20ms/Div

Enable Response



C_{IN}=1µF,C_{OUT}=1µF
I_{OUT1}=I_{OUT2}=10mA
CH1:V_{EN},5V/Div, DC
CH2:V_{OUT1},1V/Div, DC
CH3:V_{OUT2},1V/Div, DC
TIME:40µs/Div

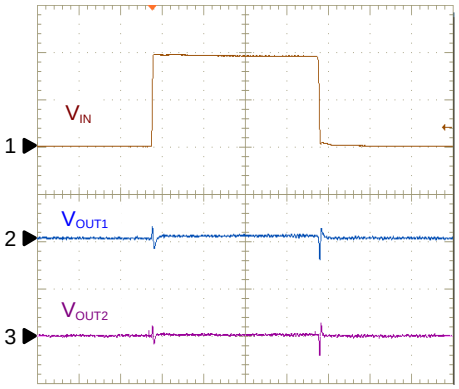
Disable Response



C_{IN}=1µF,C_{OUT}=1µF
I_{OUT1}=I_{OUT2}=50mA
CH1:V_{EN},5V/Div, DC
CH2:V_{OUT1},1V/Div, DC
CH3:V_{OUT2},1V/Div, DC
TIME:40µs/Div

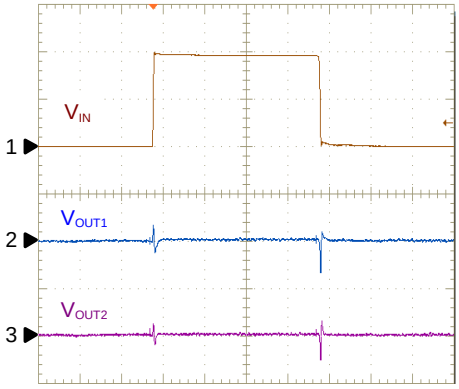
Operating Waveforms

Line Transient Response



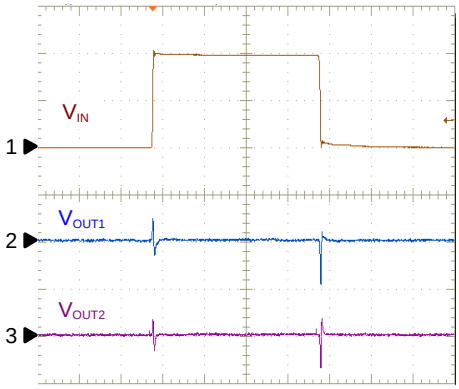
V_{IN}=3.8V to 4.8V to 3.8V (rise / fall time = 4µs)
C_{IN}=1µF,C_{OUT}=1µF
I_{OUT1}=I_{OUT2}=10mA
CH1:V_{IN},500mV/Div, DC,Offset=3.8V
CH2:V_{OUT1},20mV/Div, DC,Offset=3.3V
CH3:V_{OUT2},20mV/Div, DC,Offset=1.8V
TIME:100µs/Div

Line Transient Response



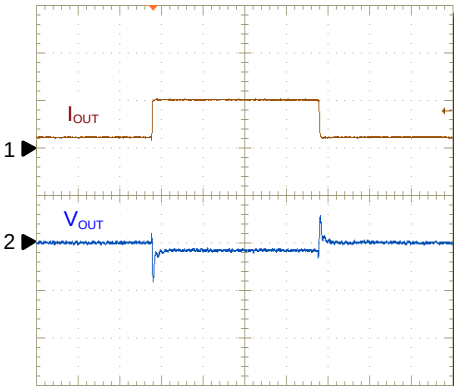
V_{IN}=3.8V to 4.8V to 3.8V (rise / fall time = 4µs)
C_{IN}=1µF,C_{OUT}=1µF
I_{OUT1}=I_{OUT2}=50mA
CH1:V_{IN},500mV/Div, DC,Offset=3.8V
CH2:V_{OUT1},20mV/Div, DC,Offset=3.3V
CH3:V_{OUT2},20mV/Div, DC,Offset=1.8V
TIME:100µs/Div

Line Transient Response



V_{IN}=3.8V to 4.8V to 3.8V (rise / fall time = 4µs)
C_{IN}=1µF,C_{OUT}=1µF
I_{OUT1}=I_{OUT2}=100mA
CH1:V_{IN},500mV/Div, DC,Offset=3.8V
CH2:V_{OUT1},20mV/Div, DC,Offset=3.3V
CH3:V_{OUT2},20mV/Div, DC,Offset=1.8V
TIME:100µs/Div

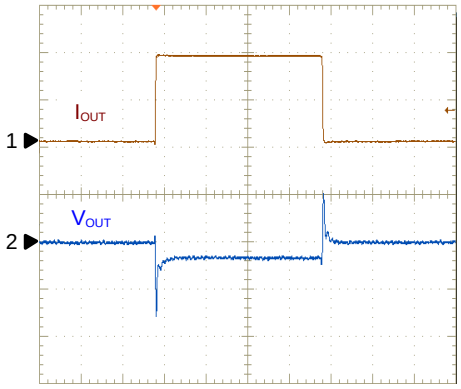
Load Transient Response



I_{OUT}=10mA to 50mA to 10mA (rise / fall time = 1µs)
C_{IN}=1µF,C_{OUT}=1µF
CH1:I_{OUT},50mA/Div, DC
CH2:V_{OUT},20mV/Div, DC,Offset=3.3V
TIME:40µs/Div

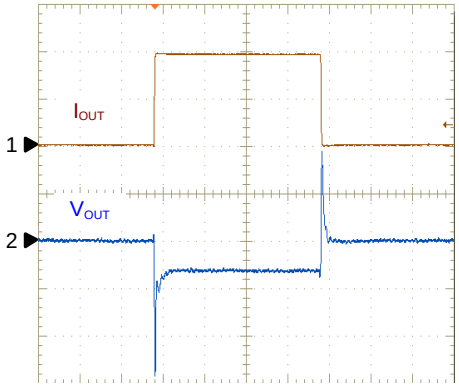
Operating Waveforms

Load Transient Response



I_{OUT}=10mA to 100mA to 10mA (rise / fall time = 1µs)
C_{IN}=1µF,C_{OUT}=1µF
CH1:I_{OUT},50mA/Div, DC
CH2:V_{OUT},20mV/Div, DC,Offset=3.3V
TIME:40µs/Div

Load Transient Response

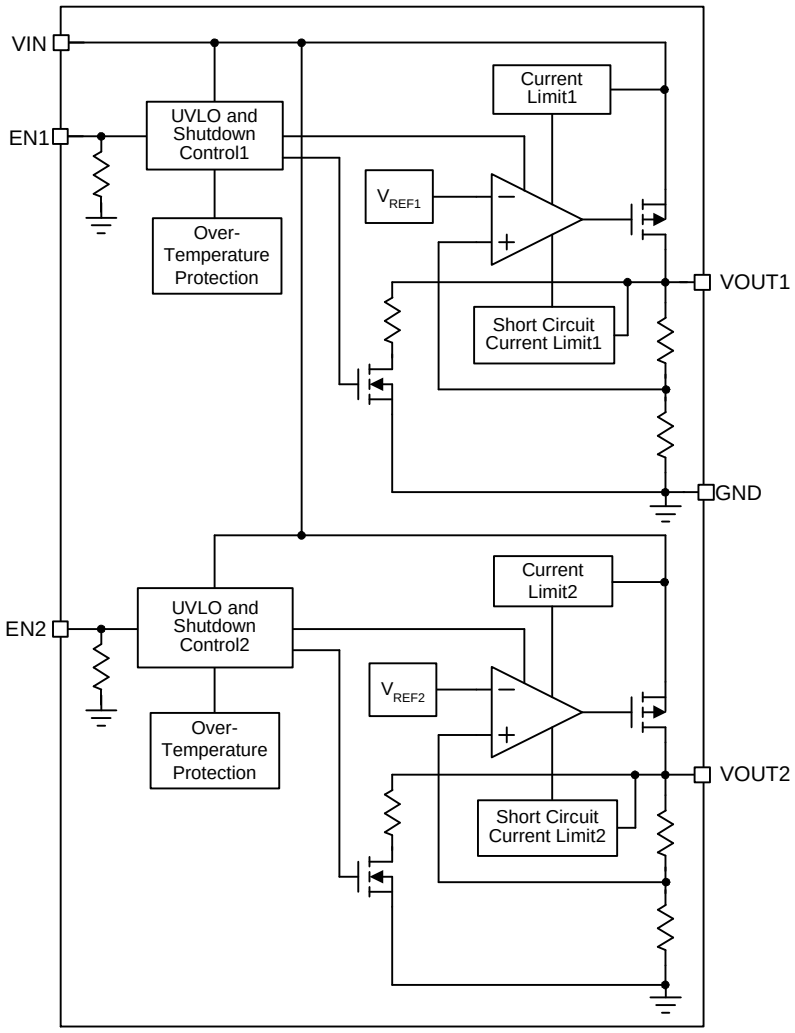


I_{OUT}=10mA to 200mA to 10mA (rise / fall time = 1µs)
C_{IN}=1µF,C_{OUT}=1µF
CH1:I_{OUT},100mA/Div, DC
CH2:V_{OUT},20mV/Div, DC,Offset=3.3V
TIME:40µs/Div

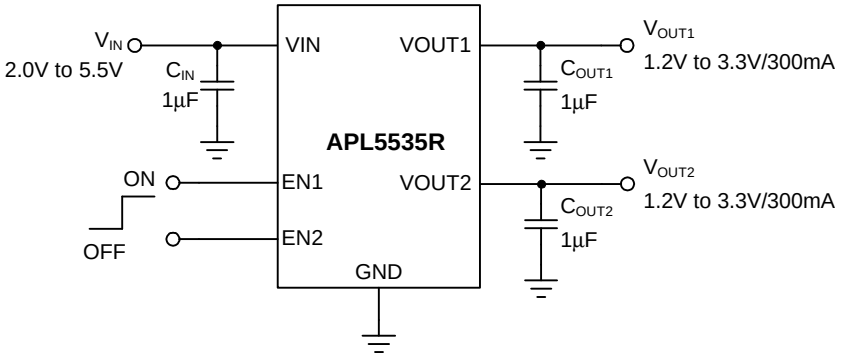
Pin Description

PIN		FUNCTION
NO.	NAME	
1, 3	EN1, EN2	Enable Input. Pulling the VEN1/2 above 1.5V enables the respective regulator output; pulling VEN1/2 below 0.4V disables the respective regulator output.
2	IN	Input Supply Pin. V_{IN} can range from 2V to 5.5V and should be bypassed with at least a 1μF capacitor.
4	GND	Ground pin of the circuitry. All voltage levels are measured with respect to this pin.
5	OUT2	Regulator Outputs. Sources up to 300mA. Bypass with at least a 1μF capacitor to the GND respectively.
6	OUT1	

Block Diagram



Typical Application Circuit



Function Description

VIN Under-Voltage Lockout (UVLO)

The APL5535R has a built-in under-voltage lockout circuit to keep the outputs shuting off until internal circuitry is operating properly. The UVLO circuit has a hysteresis and a de-glitch feature so that it will typically ignore undershoot transient on the input.

Soft-Start (For Each Channel)

The APL5535R provides an internal soft-start circuitry to control rise rate of the output voltage and limit the current surge during start-up. The output voltage starts the soft-start at approximate 60μs after the VIN is over the UVLO threshold. The typical soft-start interval is about 60μs.

Current-Limit Protection (For Each Channel)

The APL5535R provides a current-limit protection function. During current limit, the device limits output current at current limit threshold. For reliable operation, the device should not be operated in current limit for extended period.

Short-Circuit Current-Limit Protection (For Each Channel)

When the output voltage drops below 0.8V, which is caused by the over load or short circuit, the device limits the output current down to a safe level. The short circuit current limit is used to reduce the power dissipation during short circuit conditions. If the junction temperature is over the over-temperature threshold, the device will enter the thermal shutdown.

Enable/Disable (For Each Channel)

Pulling the $V_{EN1/2}$ above 1.5V enables the respective LDO output, and pulling $V_{EN1/2}$ below 0.4V disables the respective LDO output. When both the LDO outputs are disabled, the supply current is reduced to less than 1μA. EN1/2 pins are internally pulled low by resistors. If shutdown function is not used, connect EN1/2 to VIN for normal operation. The enable inputs are compatible with both TTL and CMOS logic levels.

Over-Temperature Protection

An over-temperature protection circuitry limits the junction temperature of APL5535R. When the junction temperature exceeds +160°C, the over-temperature protection circuitry disables the LDO outputs, allowing the device to cool down. The LDO outputs are enabled again after the junction temperature cools down by 40°C, resulting in a pulsed output during continuous thermal overload conditions. Over-temperature protection is designed to protect the IC in the event of over temperature conditions. For reliable operation, the junction temperature cannot exceed T_J=+125°C

Application Information

Input Capacitor

The APL5535R requires proper input capacitors to supply surge current during stepping load transients to prevent the input rail from dropping. Because the parasitic inductor from the voltage sources or other bulk capacitors to the VIN limit the slew rate of the surge current, place the Input capacitors near VIN as close as possible. Input capacitors should be larger than 1μF and a minimum ceramic capacitor of 1μF is necessary.

Output Capacitor

The APL5535R needs a proper output capacitor to maintain circuit stability and improve transient response over temperature and current. In order to insure the circuit stability, the proper output capacitor value should be larger than 1μF. With X5R and X7R dielectrics, 1μF is sufficient at all operating temperatures. Large output capacitor value can reduce noise and improve load-transient response and PSRR, Figure 1 shows the curves of allowable ESR range as the function of load current for various output capacitor values.

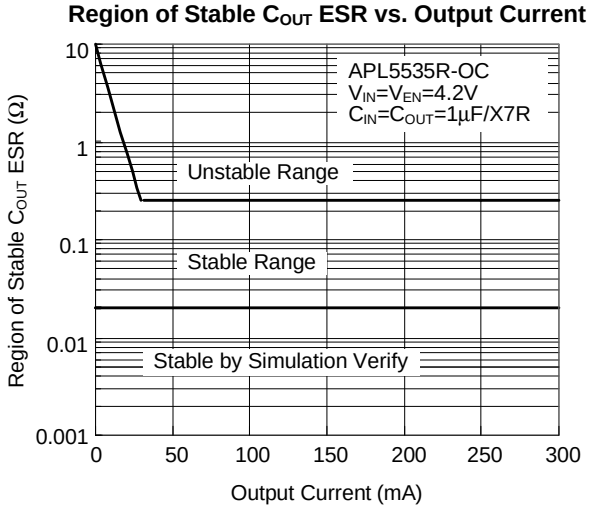


Figure1. Stable C_{OUT} ESR Range

Operation Region and Power Dissipation

The APL5535R maximum power dissipation depends on the thermal resistance and temperature difference between the die junction and ambient air. The TDFN1.6x 1.6-6 package power dissipation P_D across the device is:

$P_D = (T_J - T_A) / \theta_{JA}$

where (T_J-T_A) is the temperature difference between the junction and ambient air. θ_{JA} is the thermal resistance between Junction and ambient air. Assuming the T_A=25°C and maximum T_J=160°C (typical thermal limit threshold), the maximum power dissipation is calculated as:

P_D(max)=(160-25)/165 = 0.82(W)

For normal operation, do not exceed the maximum junction temperature rating of T_J = 125°C. The calculated power dissipation should be less than:

P_D =(125-25)/165 = 0.61(W)

The GND provides an electrical connection to the ground and channels heat away. Connect the GND to the ground by using a large pad or a ground plane.

Layout Consideration

Figure 2 illustrates the layout. Below is a checklist for your layout:

1. Please place the input capacitors close to the VIN.
2. Ceramic capacitors for load must be placed near the load as close as possible.
3. To place APL5535R and output capacitors near the load is good for performance.
4. Large current paths, the bold lines in figure 2, must have wide tracks.

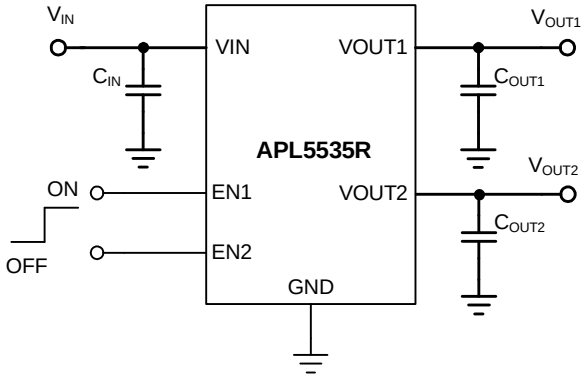
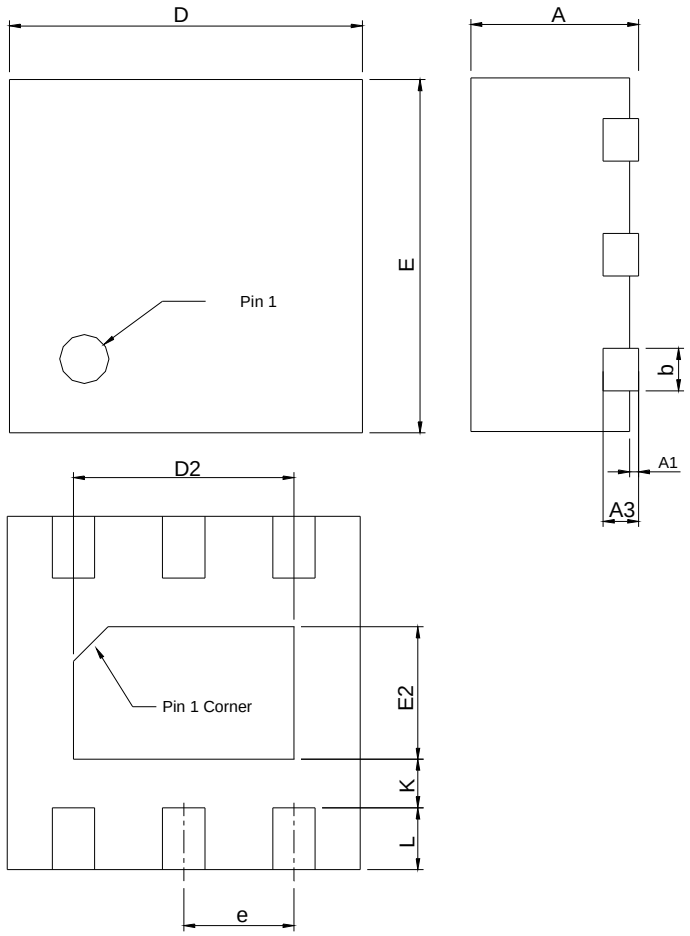


Figure2. Large Current Paths

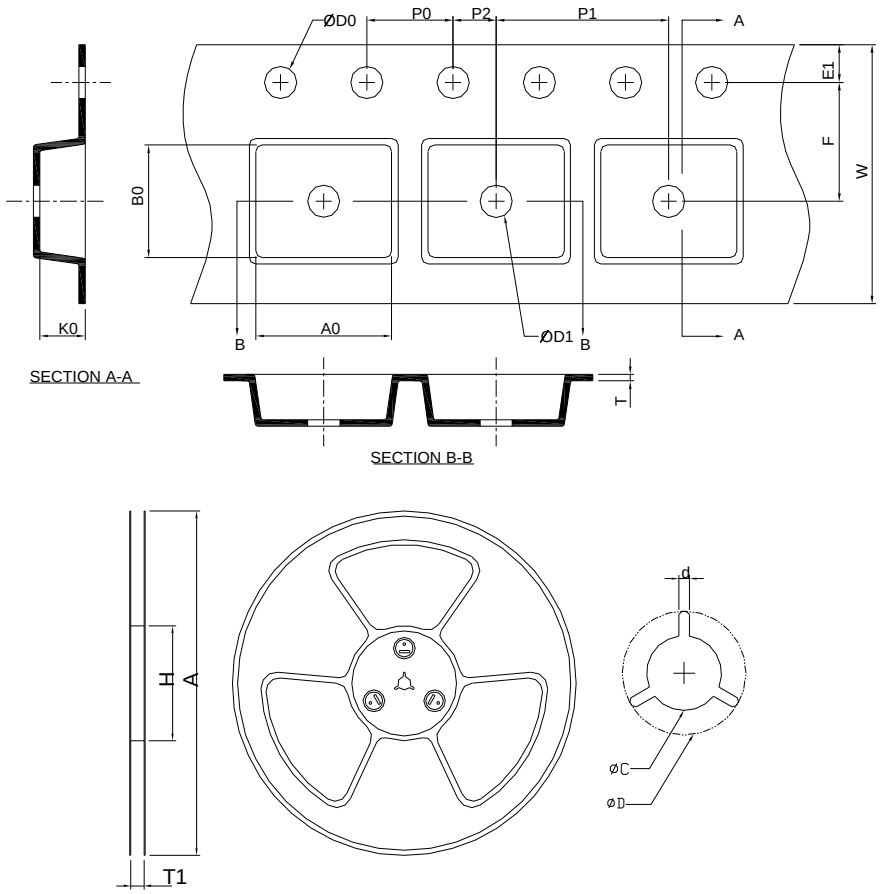
Package Information

TDFN1.6x1.6-6



SYMBOL	TDFN1.6x1.6-6			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.70	0.80	0.028	0.031
A1	0.00	0.05	0.000	0.002
A3	0.20 REF		0.008 REF	
b	0.20	0.30	0.008	0.012
D	1.55	1.65	0.061	0.065
D2	0.95	1.05	0.037	0.041
E	1.55	1.65	0.061	0.065
E2	0.55	0.65	0.022	0.026
e	0.50 BSC		0.020 BSC	
K	0.20	-	0.008	-
L	0.19	0.29	0.007	0.011

Carrier Tape & Reel Dimensions



Application	A	H	T1	C	d	D	W	E1	F
TDFN1.6x1.6-6	178.0±2.00	50 MIN.	8.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	8.0±0.30	1.75±0.10	3.5±0.05
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.0±0.10	4.0±0.10	2.0±0.05	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	1.70±0.20	1.70±0.20	0.90±0.20

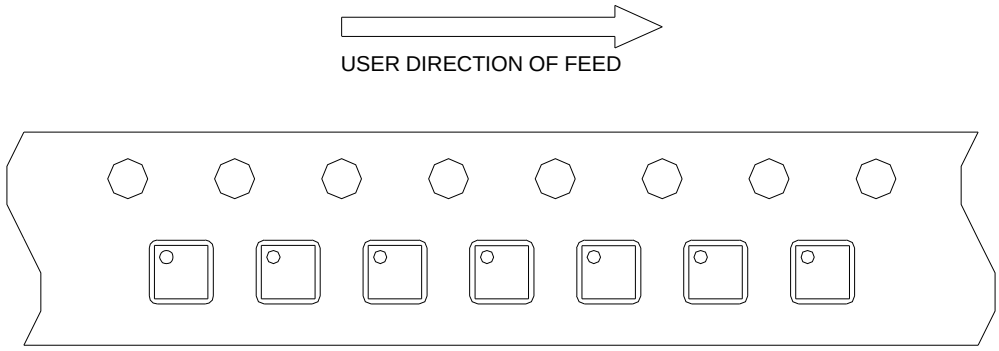
(mm)

Devices Per Unit

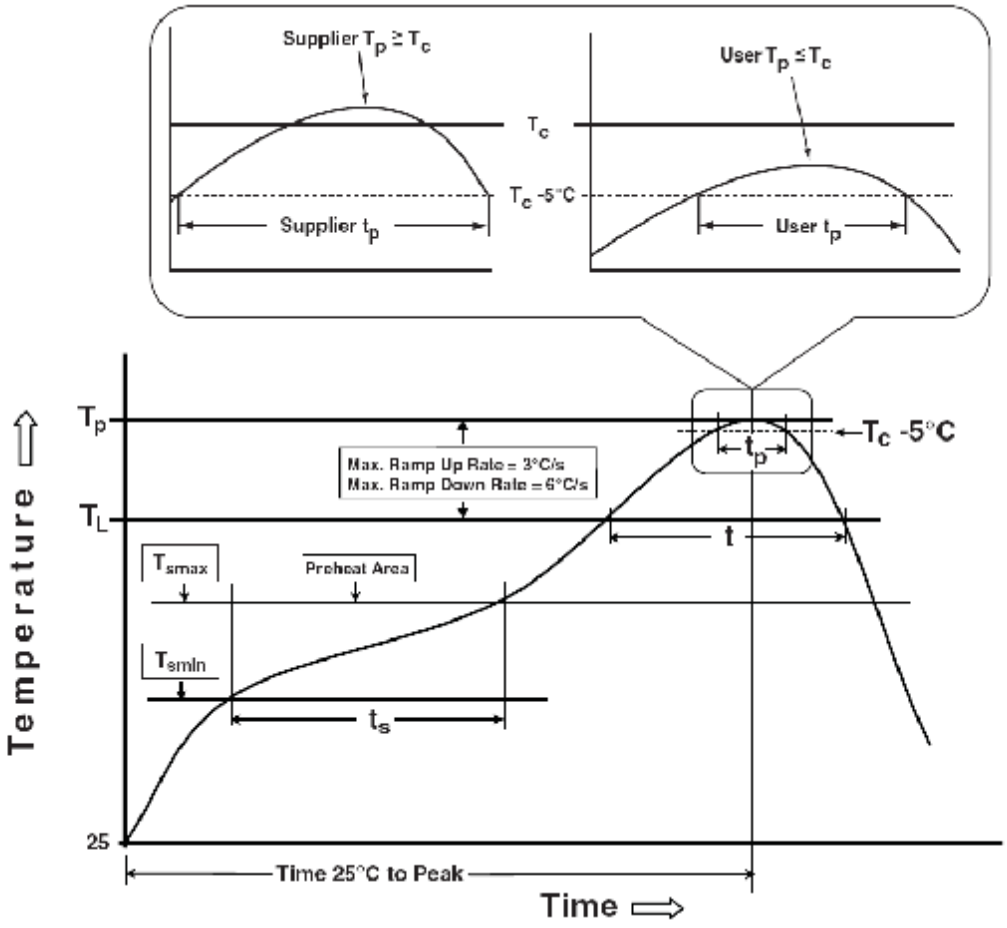
Package Type	Unit	Quantity
TDFN1.6x1.6-6	Tape & Reel	3000

Taping Direction Information

TDFN1.6x1.6-6



Classification Profile



Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Preheat & Soak Temperature min (T_{smin}) Temperature max (T_{smax}) Time (T_{smin} to T_{smax}) (t_s)	100 °C 150 °C 60-120 seconds	150 °C 200 °C 60-120 seconds
Average ramp-up rate (T_{smax} to T_P)	3 °C/second max.	3°C/second max.
Liquidous temperature (T_L) Time at liquidous (t_L)	183 °C 60-150 seconds	217 °C 60-150 seconds
Peak package body Temperature (T_p)*	See Classification Temp in table 1	See Classification Temp in table 2
Time (t_P)** within 5°C of the specified classification temperature (T_c)	20** seconds	30** seconds
Average ramp-down rate (T_p to T_{smax})	6 °C/second max.	6 °C/second max.
Time 25°C to peak temperature	6 minutes max.	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. SnPb Eutectic Process – Classification Temperatures (Tc)

Package Thickness	Volume mm^3 <350	Volume mm^3 ³350
<2.5 mm	235 °C	220 °C
≥2.5 mm	220 °C	220 °C

Table 2. 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 °C	260 °C	260 °C
1.6 mm – 2.5 mm	260 °C	250 °C	245 °C
≥2.5 mm	250 °C	245 °C	245 °C

Reliability Test Program

Test item	Method	Description
SOLDERABILITY	JESD-22, B102	5 Sec, 245°C
HOLT	JESD-22, A108	1000 Hrs, Bias @ T_j=125°C
PCT	JESD-22, A102	168 Hrs, 100%RH, 2atm, 121°C
TCT	JESD-22, A104	500 Cycles, -65°C~150°C
HBM	MIL-STD-883-3015.7	VHBM≧2KV
MM	JESD-22, A115	VMM≧200V
Latch-Up	JESD 78	10ms, 1_{tr}≧100mA

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