DD313-4

40V Adjustable Current Sink Linear LED Driver

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General Description

The DD313-4 IC is an economical, versatile, and robust device designed to provide cost-effective solution for regulating constant current in applications such as LED lighting over a 4.5 V to 40 V wide range of supply voltage which allows for single supply voltage operation from industry standard 5V, 12 V, 18 V, 24 V, 36 V power rails. The device is designed to operate as a constant current source.

The output current of DD313-4 (up to 120 mA) is set by an external resistor. The output current can be dimmed by digital PWM duty (up to 1 MHz to prevent flickering).

Provision such as an over temperature shutdown/alarm function insures damage avoidance under an overheated operating condition. The LED open detection function is also included to provide fault detection with a fault status reported through open-drain output ALARM pin. The 40 volt high voltage output is implemented to withstand surges common in automobile, industrial, and commercial lighting applications.

The DD313-4 comes with SOT26 thermally robust packages.

Features

- Wide operating voltage range with self-bias power supply (4.5 V to 40 V)
- Constant current regulator
    - Low reference voltage (V_{SENSE} = 0.65V)
    - Integrated MOSFET with on resistance less than 2.9 Ω
    - Output current: 2mA ~ 120 mA
    - Channel current deviation among devices: ±3%
- PWM dimming up to 1 MHz (invisible flickering)
- Voltage surge (40 V) suppressing for LED protection
- Low temperature drift: ±5% over -40 $^{\circ}$C to +85 $^{\circ}$C
- High power supply rejection ratio: -64 dB (A/V)
- LED open circuit detection
- Thermal shutdown and pre-thermal warning
- SOT26 thermal robust package

Application

- General Illumination, Channel Lettering
- Decorative Lighting, Pool Lighting, Landscaping Lighting
- Instrument and Industrial Instrumentation
- White Goods
- Offline LED Luminaries

Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted)[1]

CHARACTERISTIC	SYMBOL	MIN	NOM	MAX	UNIT
Voltage[2]	V_{CC}	-0.3	-	40	V
	PWM IN	-0.3	-	5.5	V
	IOUT	-0.3	-	40	V
	ALARM OUT	-0.3	-	6	V
Current	IOUT[3]	0	-	120	mA
	ALARM OUT	0	-	3	mA
Temperature	Operating junction T_j	-40	-	150	$^{\circ}$C
	Storage T_{STG}	-55	-	150	$^{\circ}$C
Electrostatic Discharge Ratings	Human body mode (HBM)	2000	-	-	V
	Machine mode (MM)	200	-	-	V

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[1] 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-rated conditions for extended periods my affect device reliability

[2] All Voltages are with respect to device ground terminal.

[3] The maximum allowable current through IOUT is determined by power dissipation, operating temperature and chip/package reliability. 120 mA is the maximum sink current in IOUT. It is an upper bound solely based on chip/package reliability.

Thermal Information

PACKAGES	JUNCTION TO AMBIENT (θ_{JA}) - $^\circ$C/W	CONDITIONS
SOT26	335	Device mounted on FR4 PCB with minimum pad layout
	143	Device mounted on 25mm x 25mm 2oz copper board
	120	Device mounted on 50mm x 50mm 2oz copper board

Recommended Operating Conditions

At T_A = -40°C to 110°C, unless otherwise noted

PARAMETER		SYMBOL	TEST CONDITIONS	MIN	NOM	MAX	UNIT
DC Characteristics V_{CC} = 4.5 to 40 V	Supply Voltage	V_{CC}	-	4.5		40	V
	Output Voltage	V_O	Drive turned on			V_{CC}	V
			Drive turned off			V_{CC}	V
			ALARM OUT	-0.3		6	V
	Open drain sink current	I_{OUT}	ALARM OUT		1	3	mA
	Output sink current (IOUT)	I_{OUT}		1		120	mA
	High level input voltage	V_{IH}	PWM IN	2.3		5.5	V
	Low level input voltage	V_{IL}	PWM IN	-0.3		1.0	V
AC Characteristics V_{CC} = 4.5 to 40 V	PWM dimming frequency	f_{PWM}	PWM IN			1	MHz

Electrical Characteristics

At V_{cc} = 4.5 to 40 V, T_A = -40°C to 85°C. Typical values at V_{cc} = 24 V and T_A = 25°C, unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Driver Characteristic						
Leakage output current	I_{OL}	IOUT = 40V, driver off			0.36	µA
Constant current error (device-to-device)	ΔI_{OL1}	IOUT, 100% PWM duty, V_{OUT} = 1.0 V, R_{EXT} = 33 Ω (~ 20 mA)		3		%
Line regulation	ΔI_{OL2}	IOUT, 100% PWM duty, V_{OUT} =1.0 V, R_{EXT} = 33 Ω (~ 20 mA)		0.01		%/V
Load regulation	ΔI_{OL3}	IOUT, 100% PWM duty, V_{OUT} = 1.0 ~ 10V, R_{EXT} = 33 Ω (~ 20 mA)		0.01		%/V
Temperature drift	ΔI_{OL4}	Junction temperature < 125°C	-5		5	%
Current Sensing						
Current sensing voltage	V_{SENSE}			650		mV
Regulated Supply						
PSRR	V_{PSRR}	DC to 1MHz (V_{CC} = 24 V), IOUT = 20mA		-64		dB
PSRR	V_{PSRR}	DC to 1MHz (V_{CC} = 36 V), IOUT = 20mA		-64		(A/V)
Turn on time	t_{ON}				500	µs
Temperature Sensor						
Thermal alarm threshold	T_{ALM}	Junction temperature (T_J)	100	115	130	°C
Thermal shutdown threshold	T_{SHD}	Junction temperature (T_J)	150	165	175	°C
Thermal error hysteresis	T_{HYS}	Junction temperature (T_J)	5	10	20	°C
PWM Function						
Pull-high resistor	R_{PH}	Connected between internal supply (4.4 V) and PWM IN pin	4.0			KΩ
LED Open Detection						
LED open detection threshold	V_{LO}				0.3	V
ALARM Function						
Pull-high resistor	R_{PH}	Connected between internal supply (4.4 V) and ALARM OUT pin	90			KΩ
Open drain current	I_{OD}	Vout = 0.4 V		2.3		mA
Supply Current						
Supply current	I_{CC}	100% PWM duty, R_{EXT} = 33 Ω (~ 20 mA)		1.1		mA
		100% PWM duty, R_{EXT} = 13 Ω (~ 50 mA)		1.1		
		100% PWM duty, R_{EXT} = 6.5 Ω (~ 100 mA)		1.1		

Switching Characteristics[4]

At V_{cc} = 6 V to 40 V, T_A = -40°C to 85°C, C_L = 15 pF, R_L = 82 Ω

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Propagation delay	t_{D0}	PWM IN to IOUT (rising edge)		73		ns
	t_{D1}	PWM IN to IOUT (falling edge)		28		ns
Rise time	t_{R0}	VOUT = 1 V; IOUT = 20 mA		77		ns
	t_{R1}	VOUT = 1.1 V; IOUT = 50 mA		101		ns
		VOUT = 1.25V; IOUT = 100 mA		128		ns
Fall time	t_{F0}	VOUT = 1 V; IOUT = 20 mA		78		ns
	t_{F1}	VOUT = 1.1 V; IOUT = 50 mA		111		ns
		VOUT = 1.25V; IOUT = 100 mA		139		ns

Parameter Measurement Information

Test Circuits
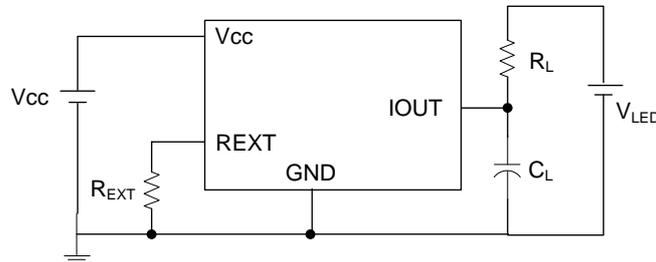
Figure 1. Rise and fall time test circuit for IOUT
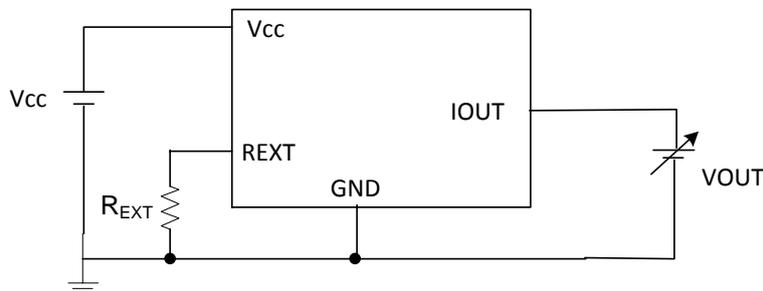
Figure 2. Constant current test circuit for IOUT

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[4] IOUT switching characteristics are given in configuration register section
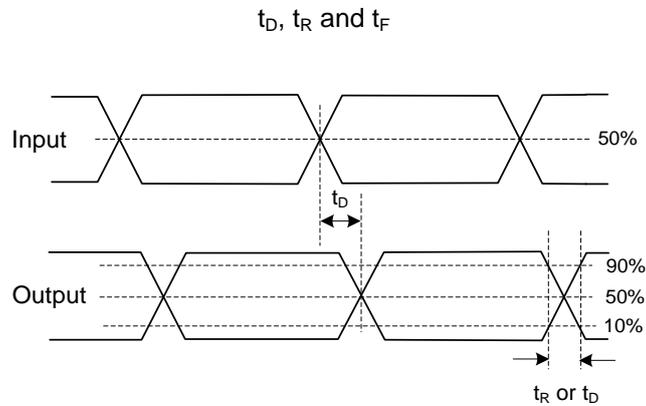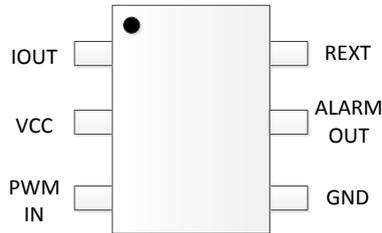
Timing Diagram

t_D, t_R and t_F

Figure 3. Output timing

Pin Description

PIN NAME	I/O	DESCRIPTIONS
IOUT	O	Low output voltage constant current sink output
VCC	-	Supply voltage
REXT	I/O	A resistor between REXT and GND sets maximum current
PWM IN	I	PWM input
GND	-	Ground
ALARM OUT	O	Open drain output for reporting LED open circuit and driver thermal issue

SOT26

Typical Characteristics
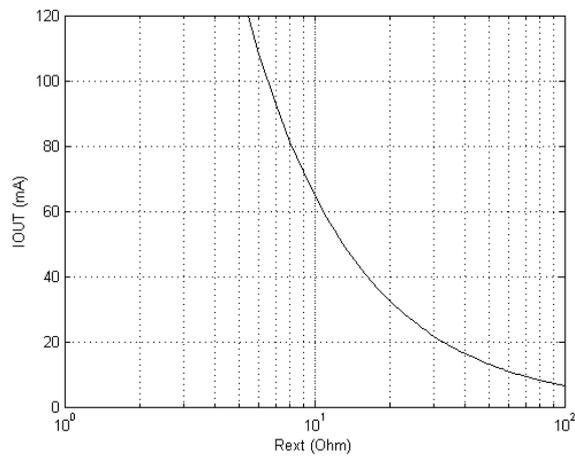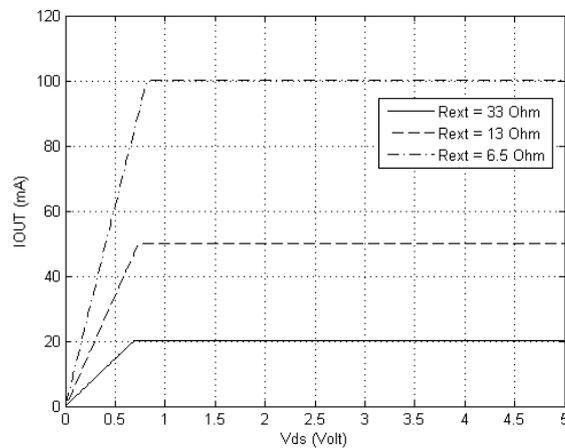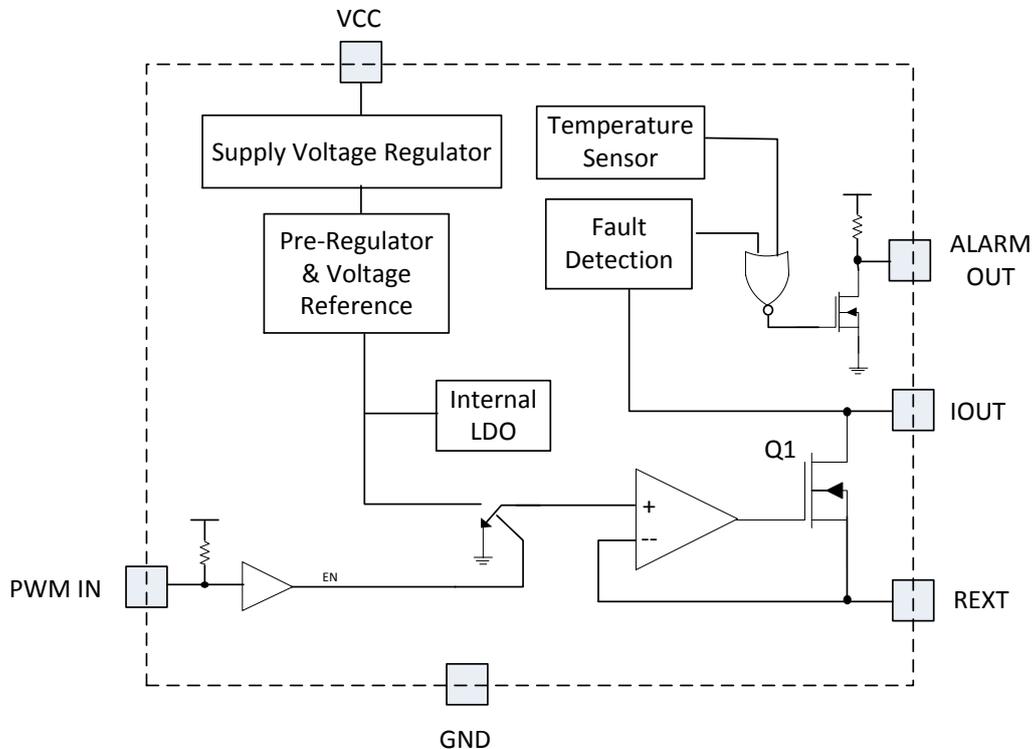

Figure 4. Reference resistor vs. output current

Figure 5. IOUT vs. output voltage (Vcc = 4.5 ~ 40 V)

Functional Block Diagram

Detailed Description

PWM Dimming

The DD313-4 supports PWM dimming. The dimming information is retrieved from PWM IN into which a microcontroller sends a PWM signal with allowable frequency up to 1 MHz. If the PWM IN pin is floating, the driver is always on. Otherwise the driver is modulated by patterns appearing in the PWM IN pin.

Constant Current Setting

The maximum constant current for is determined by an external resistor, R_{EXT}, placed between the REXT and GND pins. The R_{EXT} resistor value is calculated with the equation below.

$$I_{OUT} \text{ (A)} = V_{REXT} \text{ (V)} / R_{EXT} \text{ (}\Omega\text{)}$$

where V_{REXT} is the internal reference voltage on the REXT pin (typical 0.65 V)

LED Open Detection

The DD313-4 can detect LED open circuit (LO) by comparing with open circuit threshold when IOUT is on. LO will result in ALARAM signal pulled low. Figure 6 illustrates LO detection circuit. The table below shows a truth table for LO.

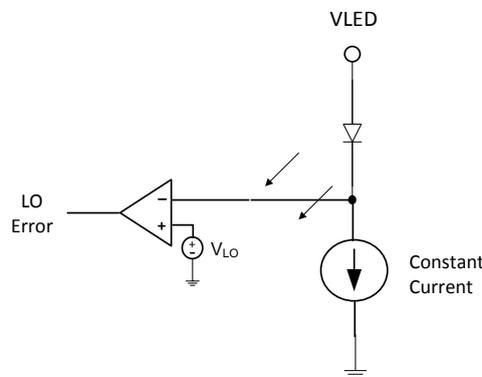| LO	Alarm
LED is not open circuit ($V_{OUT} > V_{LO}$)	0
LED is open circuit ($V_{OUT} < V_{LO}$)	1

Figure 6. LED Open Circuit Detection Circuit

Thermal Alarm and Shutdown

The DD313-4 has an on-chip temperature sensor for thermal alarm (TA) and shutdown (TS) protection. If the junction temperature of a device exceeds the thermal alarm threshold, ALARM output will be set to high. If the junction temperature reaches to a TS threshold, the device will turn off outputs with ALARM remaining high until the junction temperature falls below thermal error hysteresis of TA threshold. If the junction temperature is lower than a thermal error hysteresis of TA threshold, the device will turn back on automatically.

Power Dissipation Calculation

The device power dissipation must be lower than the power dissipation rate of the device package material as illustrated in Figure 7 to ensure a correct operation. The equation below calculates the power dissipation of a device.

$$P_D = I_{CC} \times V_{CC} + [I_{MAX} \times V_{OUT} \times D_{PWM}]$$

Where:

V_{CC} = device supply voltage

I_{CC} = device supply current

V_{OUT} = IOUT voltage when driving LED current

I_{MAX} = LED current adjusted by REXT resistor

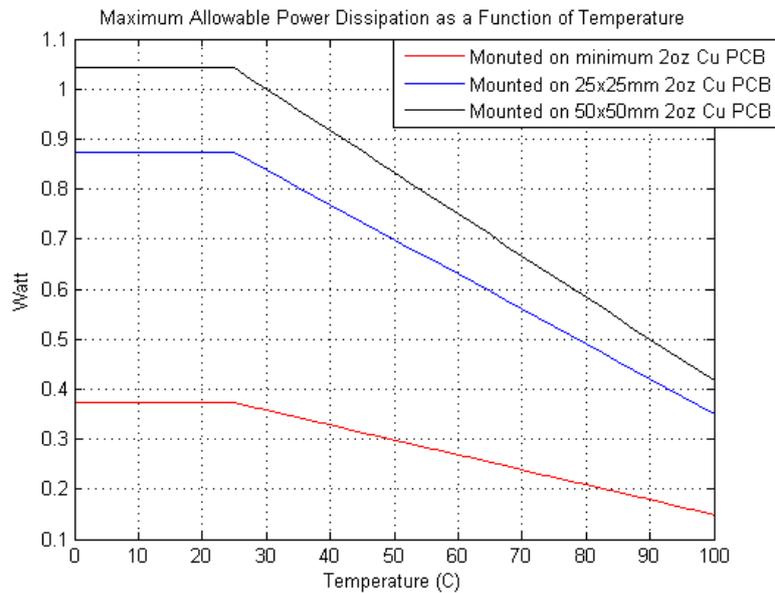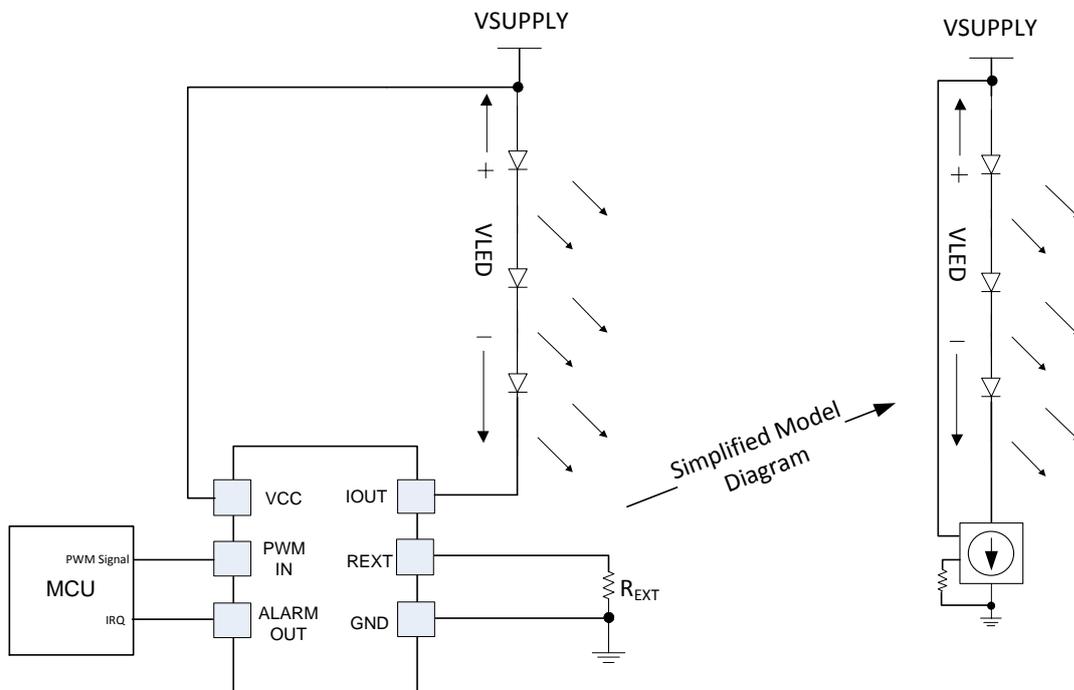D_{PWM} = average duty ratio defined by scaled PWM duty

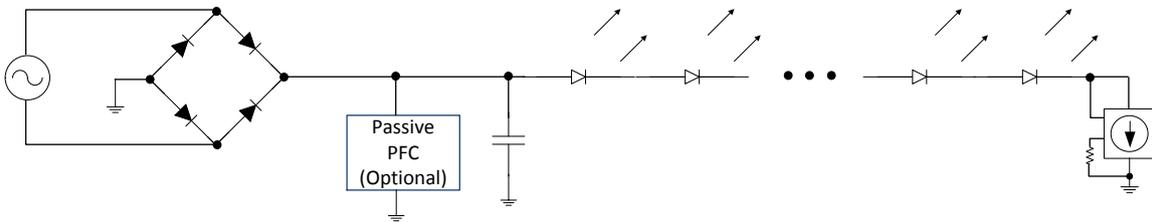Figure 7. Power dissipation vs. temperature

Application Circuits

The application circuits below show the versatility of DD313-4 platform for building applications with desirable features in LED lighting.
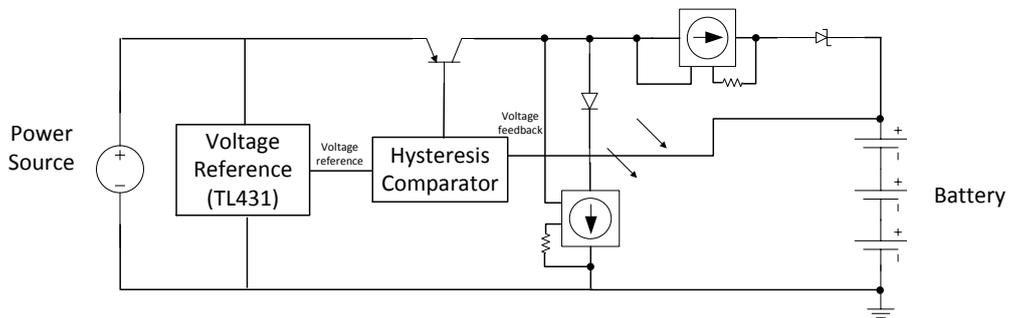
Linear Constant Current Driver

Lighting LED String
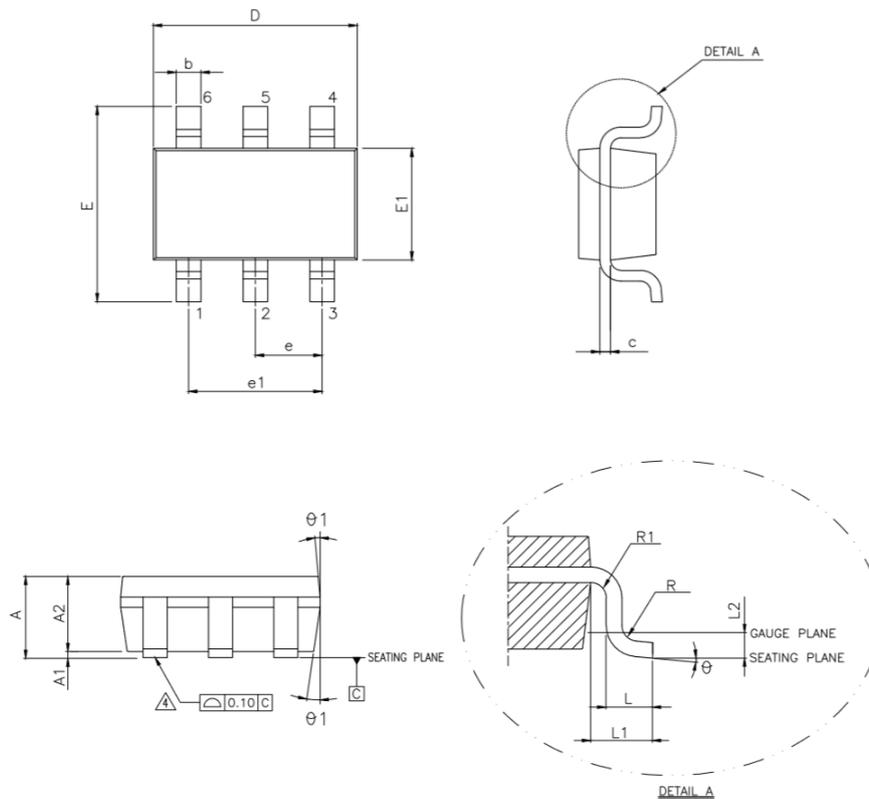
Basic AC Application

Constant Current Regulator Charging Circuit

Package Dimension

VARIATION(ALL DIMENSIONS SHOWN IN MM)

SYMBOL	MIN.	NOM.	MAX.
A	–	–	1.45
A1	0.00	–	0.15
A2	0.90	1.15	1.30
b	0.30	–	0.50
c	0.08	–	0.22
D	2.90 BSC.		
E	2.80 BSC.		
E1	1.60 BSC.		
e	0.95 BSC.		
e1	1.90 BSC.		
L	0.30	0.45	0.60
L1	0.60 REF.		
L2	0.25 BSC.		
R	0.10	–	–
R1	0.10	–	0.25
θ	0˙	4˙	8˙
θ1	5˙	10˙	15˙

NOTE :
1. JEDEC OUTLINE : MO−178 AB.

The products listed herein are designed for ordinary electronic applications, such as electrical appliances, audio-visual equipment, communications devices and so on. Hence, it is advisable that the devices should not be used in medical instruments, surgical implants, aerospace machinery, nuclear power control systems, disaster/crime-prevention equipment and the like. Misusing those products may directly or indirectly endanger human life, or cause injury and property loss.

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