



ZD3202

Low Noise, High Efficiency Charge-Pump Based DC/DC Converter



Features

- Low Noise, Constant Frequency Operation
- High efficiency 1.5X Charge pump
- High Output Current: Up To 125mA
- Regulated Output Voltage or Current
- Vin range: 2.7V to 4.5V
- No Inductors
- 1.5MHz Switching Frequency
- $I_{cc} < 1\mu A$ in Shutdown
- Available in 10-Pin MSOP Green Package

Applications

- White LED Backlighting
- Programmable Boost Current Source
- Cellular Phones
- MP3 Players, Portable Media Players
- Digital Cameras Modules Display Backlite
- Battery Powered LCD Displays and Modules

General Description

The ZD3202 is a low noise, constant frequency, regulated DC/DC converter that uses 1.5X charge pump to increase efficiency in white LED applications. The part can be used to produce a regulated voltage or current of up to 125mA from a 2.7V to 4.5V input. Low external parts count make the ZD3202 ideally suited for small, battery-powered applications.

An internal 2-bit DAC allows LED current to be adjusted for LED brightness control. The ZD3202 also has thermal shutdown protection and can survive a continuous short-circuit from Vout to GND. High switching frequency enables the use of small external capacitors. A low current shutdown feature disconnects the load from Vin and reduces quiescent current to less than 1mA.

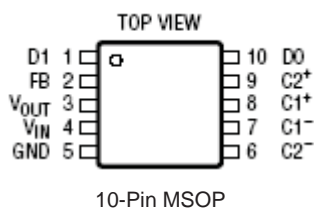
The ZD3202 is available in a 10-pin MSOP package.

Ordering Information

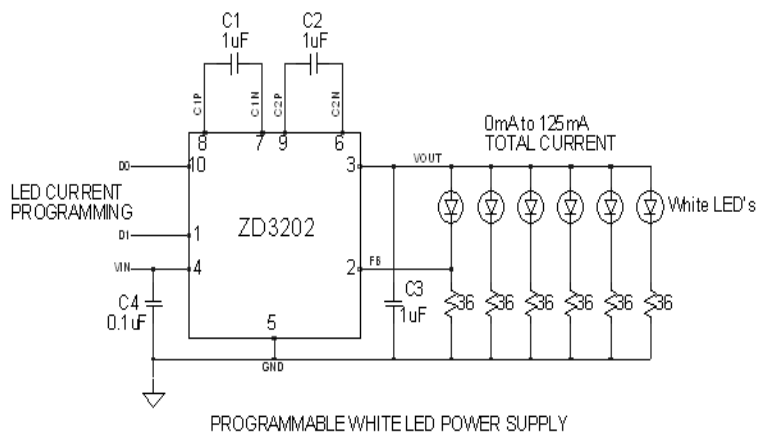
Part Number	Temperature Range	Package Type
ZD3202LEU	-40°C to +85°C	10-pin MSOP
ZD3202EVB	n/a	Evaluation Board

Please contact the factory for pricing and availability on a Tape-on-Reel option.

Pin Configuration



Typical Application



Current Setting Logic Inputs Truth Table

D1	D0	Mode
0	0	Shutdown
0	1	40mA
1	0	80mA
1	1	125mA

Based on $R_{SET} = 36\Omega$

Absolute Maximum Ratings

These are stress ratings only and functional operation of the device at these ratings or any other above those indicated in the operation sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

V_{IN}, V_{OUT} to GND.....	-0.3V to +6.0V
D0, D1	-0.3V to $V_{in} + 0.3V$
V_{OUT} Short-Circuit Duration.....	Indefinite
I_{OUT} (Note 1).....	150mA
Operation Temperature Range (Note 2)	-40 to +85°C
Maximum Junction Temperature	+150°C
Storage Temperature Range	-65 to +150°C
Lead Temperature (Soldering 10 sec)	300°C

Power Dissipation Per Package	
10-pin MSOP Thermal Resistance (θ_{JA})	157°C/W

Note 1: Based on long-term current density limitations

Note 2: The ZD3202 is guaranteed to meet performance specifications from 0°C to 70°C. Specifications over the -40°C to 85°C operating temperature range are by design, characterization and correlation with statistical process controls.

Storage Considerations

Storage in a low humidity environment is preferred. Large high density plastic packages are moisture sensitive and should be stored in Dry Vapor Barrier Bags. Prior to usage, the parts should remain bagged and stored below 40°C and 60%RH. If the parts are removed from the bag, they should be used within 168 hours or stored in an environment at or below 20%RH. If the above conditions cannot be followed, the parts should be baked for 12 hours at 125°C in order to remove moisture prior to soldering. Zywyn ships product in Dry Vapor Barrier Bags with a humidity indicator card and desiccant pack. The humidity indicator should be below 30%RH. The MSL of this product is 3.

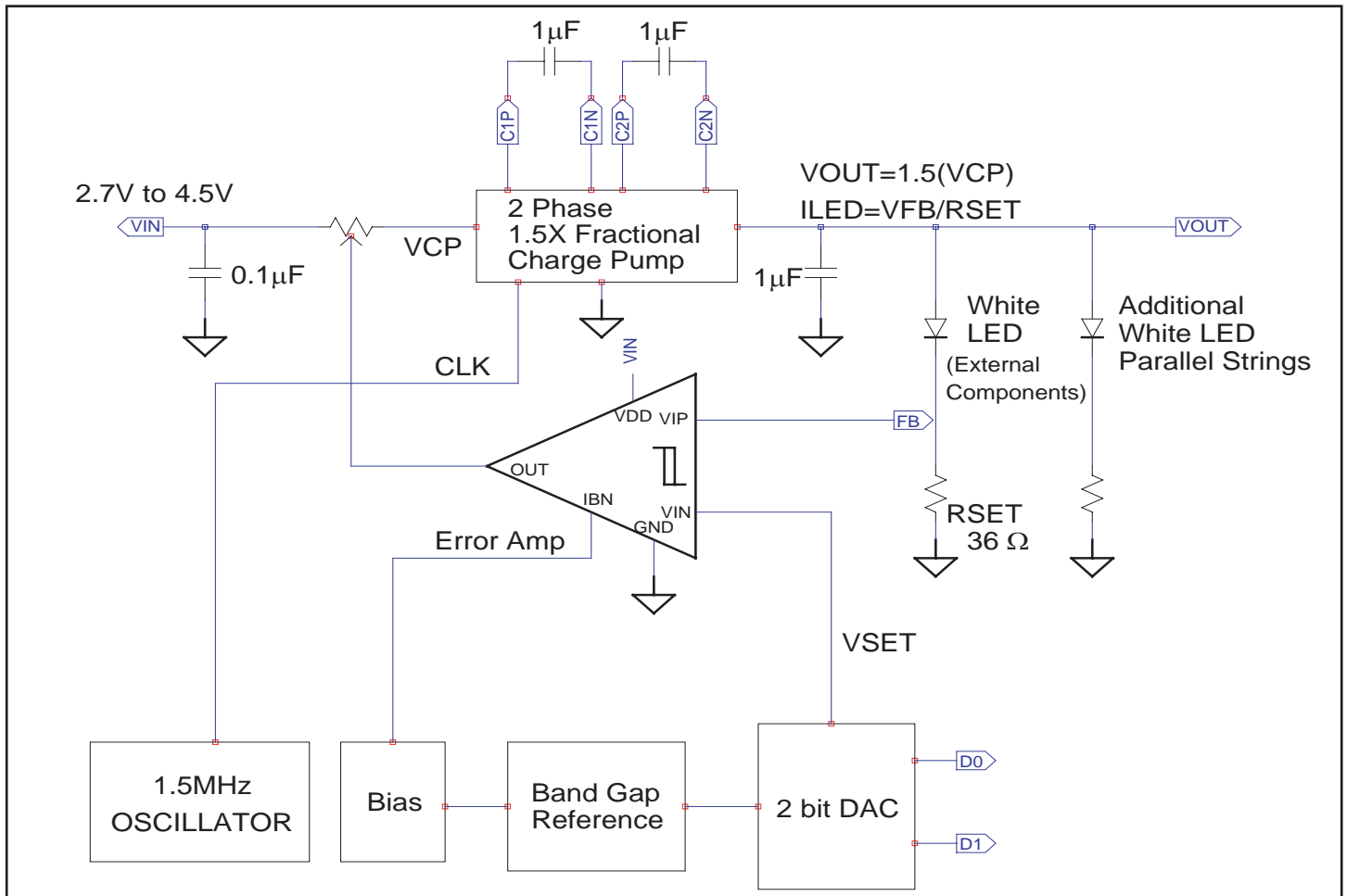
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Electrical Characteristics

Specifications are at $T_A = 25^\circ\text{C}$, $V_{IN} = 3.3\text{V}$, $R_{SET} = 36\Omega$, unless otherwise noted.

Parameter	Condition	Min	Typ	Max	Units
Input Power Supply V_{IN} Operating Voltage I_{CC} Operating Current I_{SHDNB} Shutdown Current	$I_{OUT} = 0\text{mA}$, $V_{IN} = D0 = D1 = 3.6\text{V}$ $V_{OUT} = 0\text{V}$	2.7	2.5	4.5 5 1	V mA μA
Feedback Pin Set Points $\{D0, D1\} = \{1, 0\}$ V_{FB} Setting $\{D0, D1\} = \{0, 1\}$ V_{FB} Setting $\{D0, D1\} = \{1, 1\}$ V_{FB} Setting I_{FB}	$D1 = 0, D0 = 1, I_{OUT} = 0\text{mA}, V_{IN} = 3.6\text{V}$ $D1 = 1, D0 = 0, I_{OUT} = 0\text{mA}, V_{IN} = 3.6\text{V}$ $D1 = 1, D0 = 1, I_{OUT} = 0\text{mA}, V_{IN} = 3.6\text{V}$ $V_{FB} = 0.8\text{V}$	185 430 540 -50	220 480 610	250 550 670 50	mV mV mV nA
Charge Pump R_{OL} Open Loop Output Impedance $(1.5V_{IN} - V_{OUT}) / I_{OUT}$ V_{OUT} Load Regulation (V_{OUT} / I_{OUT}) CLK Frequency	$V_{IN} = 3.3\text{V}, V_{OUT} = 4.4\text{V}, V_{FB} = 0$ $I_{OUT} = 10\text{mA to } 90\text{mA}, V_{FB} / V_{OUT} = 1$		6 0.35 1.5		Ω mV/mA MHz
Data Input, D0, D1 High Level Input Voltage (V_{IH}) Low Level Input Voltage (V_{IL}) Input Current (I_{IH}) Input Current (I_{IL})	$D1 = D0 = V_{IN}$ $D1 = D0 = 0\text{V}$	1.4 -1 -1		0.4 1 1	V V μA μA

Block Diagram



Pin Description

Pin Number	Pin Name	Pin Function
1, 10	D1, D0	Control Inputs. D0 and D1 determine the Set Point Voltage of the FB pin (see Table 1)
2	FB	FB is the Feedback Input for the regulation control loop.
3	V _{OUT}	V _{OUT} is the Output of the Charge Pump. A low impedance 1µF X5R or X7R ceramic capacitor is required from V _{OUT} to GND.
4	VIN	Input Supply Voltage. VIN should be bypassed with a 1µF to 4.7µF low impedance ceramic capacitor.
5	GND	Ground for the Charge Pump and Control Circuitry. This pin should be connected directly to a low impedance ground plane.
6, 7, 8, 9	C2 ⁻ , C1 ⁻ , C1 ⁺ , C2 ⁺	Charge Pump Flying Capacitor Pins. 1µF X5R or X7R ceramic capacitor should be connected from C1 ⁺ to C1 ⁻ and from C2 ⁺ to C2 ⁻ .

Circuit Description

The ZD3202 uses a state-of-the-art switched capacitor, fractional conversion, charge pump to boost V_{OUT} by as much as 50% above the input voltage. The charge pump switches are driven by a two-phase, non-overlapping clock that assures low EMI designs. The two-phase clock alternately charges the flying capacitors and boosts the output voltage at a free running frequency of 1.5MHz (typ).

Adjustable, Regulated Output

Regulation is provided by a feedback loop from the FB pin to the charge pump modulator, resulting in stable output voltages over the devices wide operating range. The regulated output can be adjusted with the control pins, D0 and D1. The ZD3202 integrates a digital-to-analog converter to allow dynamic, digital control of the regulated voltage. Table 1 shows the feedback Set Point Voltage as a function of D0 and D1.

D1	D0	Feedback Set Point Voltage	Output ($R_{SET}=36\Omega$)
0	0	0V	Shutdown
0	1	0.22V	40mA
1	0	0.48V	80mA
1	1	0.61V	125mA

Table 1. Feedback Control Voltage Settings

Controlled Power-Down

The ZD3202 has a low-power shutdown mode controlled by the control pins, D0 and D1. When both control pins are held at a low logic level, the ZD3202 enters power down mode and draws only leakage current from the V_{IN} supply. All internal circuitry is disabled and V_{OUT} is disconnected from V_{IN} . D0 and D1 control inputs are high impedance CMOS inputs and should not be left floating. Ensure that they are always driven with valid logic levels.

Shutdown Current

When the ZD3202 is placed in shutdown mode and while the V_{OUT} is still at a positive voltage, regulators feedback circuit will draw 5uA of current. To minimize the current draw, a bleed resistor of 10k Ω to 100k Ω can be used to draw down V_{OUT} during shutdown.

Short-Circuit/Thermal Protection

The ZD3202 has integrated short-circuit current limiting circuitry designed to protect the device. Thermal protection circuitry has also been integrated. These protection circuits allow for robust designs during manufacturing and industrial, as well as consumer environments. The current limit is set to approximately 250mA and the thermal protection will shut down the charge pump when the die temperature reaches approximately 160 $^{\circ}$ C. The charge pump will be re-started when the die temperature reaches approximately 155 $^{\circ}$ C. The ZD3202 will continue to cycle, without latchup or damage, until the fault is corrected.

Voltage or Current Programming of the ZD3202

The ZD3202 is configurable to regulate either voltage or current. In white LED applications, the ratio of the feedback set point and a sense resistor controls the current through the white LED, as shown in Figure 1. The remaining white LEDs are driven to a similar level by means of ballast resistors in series with each similar white LED.

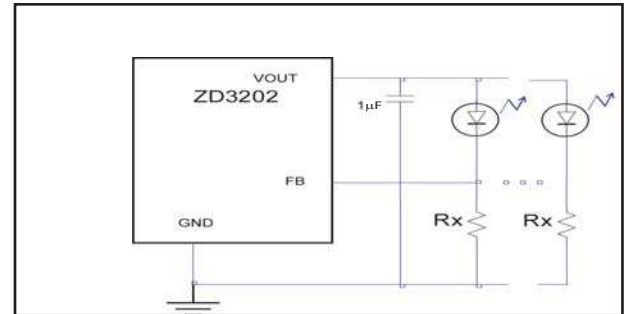


Figure 1 Current Control Mode

This configuration requires the largest amount of output capacitance to maintain stability, due to the high loop gain caused by relatively low impedance of the white LED as compared to the sense resistor.

In constant voltage applications. The output voltage is set by the ratio of two resistors and the feedback set point, as shown in Figure 2. $V_{OUT} = \text{set point voltage} * (1 + (R1/R2))$. The closed-loop output resistance is impacted by the resistor ratio R1:R2, the higher the ratio, the higher the output resistance. The output resistance is 0.35 Ω with a nominal gain of 1. Typically the total resistance of the voltage divider, R1:R2, will be in the range of several K Ω to 1M Ω .

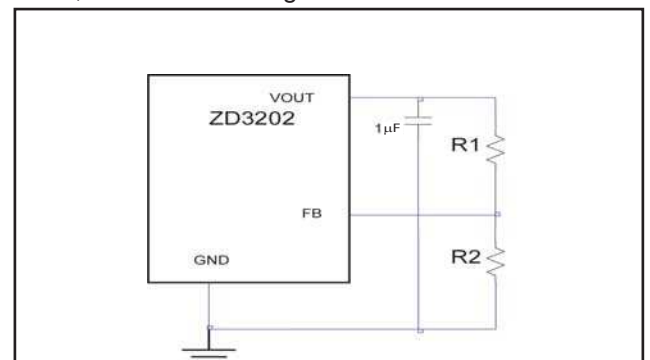


Figure 2. Voltage Control Mode

Circuit Description

In voltage mode, the highest Set Point Voltage will provide the most noise immunity and lowest closed-loop output resistance.

Charge Pump Strength

Figure 3 provides a Thevenin equivalent circuit to model the ZD3202 used to determine the amount of current available from the effective input voltage, $1.5V_{IN}$ and the effective open-loop output resistance, R_{OL} .

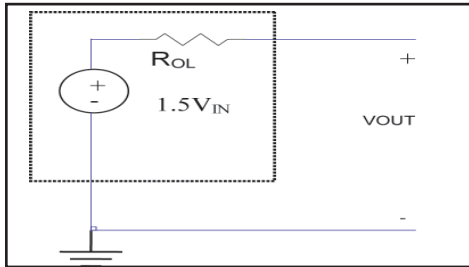


Figure 3. Equivalent Open-Loop Circuit

The available current is given by the calculated equation:

$$I_{OUT} = (1.5V_{IN} - V_{OUT})/R_{OL}$$

where R_{OL} is dependant on many factors, including oscillator frequency, capacitor value, internal switching resistance and the non-overlap period of the switching circuit.

The advantage voltage ($1.5V_{IN} - V_{OUT}$) is directly proportional to the amount of current available. V_{OUT} is dependant on the LED forward voltage and the voltage set point used. Once circuit components are selected, the amount of available current can be increased by either increasing V_{IN} or selecting a lower voltage set point. It is possible to get a 60% improvement in charge pump strength with a 100mV increase in V_{IN} .

Capacitor Selection for V_{IN} and V_{OUT}

The type and values of the capacitors chosen will impact several important parameters, including:

- Output ripple
- Regulator control loop stability
- Charge pump strength
- Start-up time

To minimize noise and ripple, ceramic capacitors, because of their low equivalent series resistance (ESR), should be used for both C_{IN} and C_{OUT} . Tantalum and aluminum capacitors should be avoided in this application.

The amount of output ripple is dependant on the value of C_{OUT} chosen and the required load current. Increasing the value of C_{OUT} will reduce output ripple while increasing both the start-up delay and start-up current. The output peak-to-peak ripple is approximated by the expression:

$$V_{RIPPLE-P} = I_{OUT}/3f_{OSC} * C_{OUT}$$

To prevent ringing or instability C_{OUT} should never be less than 0.6 μ F. The closed loop output resistance of the ZD3202 is 0.35 Ω and the output capacitor should have an ESR of less than 0.35 Ω to yield very good stability and load transient performance.

To maximize performance, the ZD3202 is designed with non-overlapping internal clocks. During this non-overlap period (~25ns) the current drawn from V_{IN} will drop to zero, requiring filtering for stable operation. V_{IN} filtering may be accomplished with a low ESR ceramic capacitor close to the V_{IN} pin. Additionally, a small (10nH) inductor may be placed in series with the ZD3202 V_{IN} supply, see Figure 4. A low cost solution for the inductor is to provide about 0.4" (1cm) of PCB trace.

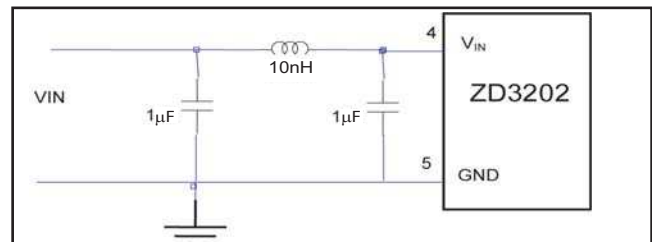


Figure 4. 10nH Inductor Used for Input Noise Reduction

Flying Capacitor Selection

Warning: Ceramic capacitors should always be used for the flying capacitors. During start-up of the ZD3202 the voltage can reverse on the flying capacitor, polarized capacitors such as tantalum or aluminum should never be used in this application.

In order to achieve the rated output current it is required to have at least 1 μ F of capacitance for each of the flying capacitors. The flying capacitors control the strength of the charge pump.

Circuit Description

The capacitors manufacturer's data sheet must be consulted to determine the proper type and value of the flying capacitors. Ceramic capacitors vary greatly, over temperature and voltage, requiring careful selection for this application. For example, X7R ceramic capacitor material will retain most of its capacitance from -40°C to +85°C, while Z5U or Y5V capacitors may lose 60% of their capacitance over their voltage rating alone. Select a ceramic capacitor that will provide the required capacitance over the voltage and temperatures range of your application.

Table 2 shows a list of ceramic capacitor manufacturers and how to contact them:

AVX	www.avxcorp.com
Kemet	www.kemet.com
Murata	www.murata.com
Taiyo Yuden	www.t-yuden.com
Vishay	www.vishay.com

Table 2. Recommended Capacitor Vendors

In very low load applications, the value of the flying capacitor may be reduced to save space and/or cost. As a guideline for selecting the starting value, the formula $R_{OL(MIN)} @ (1.5V_{IN} - V_{OUT}) / I_{OUT} = 1/2f_{OSC}C_{FLY}$. Note that the charge pump will be weaker than this theoretical formula implies.

Power Efficiency

The power efficiency (η) of the ZD3202 is similar to that of a linear regulator with an effective input voltage of 1.5 times the actual input voltage. The input current is approximately 1.5 times the load current in a 2:3 fractional charge pump. The ideal efficiency would be given by $\eta_{IDEAL} @ V_{OUT}/1.5V_{IN}$

Layout Considerations

Careful board layout is required for the ZD3202 due to its high switching frequency and the transient currents produced. Short connections to all capacitors and a true ground plane will ensure proper regulation and improve performance under all conditions. Figure 5 shows the recommended layout configuration.

Very high edge rate waveforms are present on the flying capacitor pins C1+, C2+, C1- and C2-. Energy can be capacitively coupled to adjacent printed circuit traces due to the large dv/dt on these pins. If the flying capacitors are not close to the ZD3202, magnetic fields can be generated. A Faraday shield may be used to decouple capacitive energy transfer, by placing a grounded PC trace between any sensitive nodes and the ZD3202. A ground plane should extend directly to the ZD3202 ground pin to assure a good AC ground.

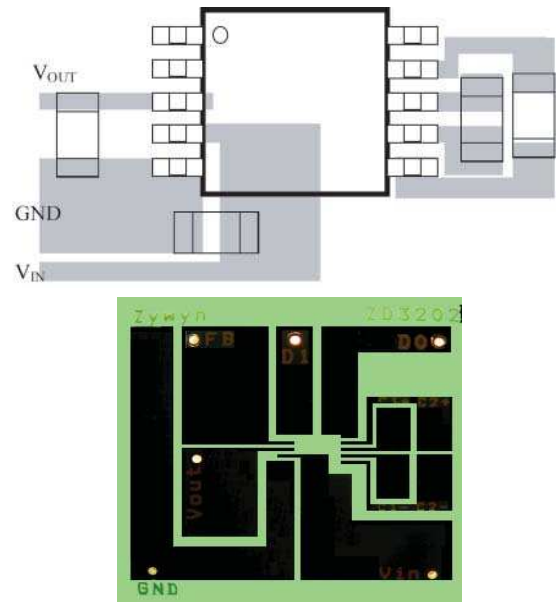


Figure 5. Recommended PCB Layout

Thermal Management

A good thermal connection to the PC board is recommended. Maintaining a solid ground plane under the ZD3202 and connecting the GND pin (Pin 5) directly to the ground plane will improve the thermal performance of the package. Maximum output current and higher input voltages can produce substantial power that needs to be dissipated. If the junction temperature of the ZD3202 reaches approximately 160°C the thermal shutdown circuitry will automatically deactivate the output.

Brightness Control Using Pulse Width Modulation

An alternative approach to dimming, is to use a pulse width modulation signal connected to both D0 and D1 pins. Linear brightness control can be achieved with frequencies from 100Hz to 500Hz, with C_{OUT} in the range of 1µF to 4.7µF. See Figure 6.

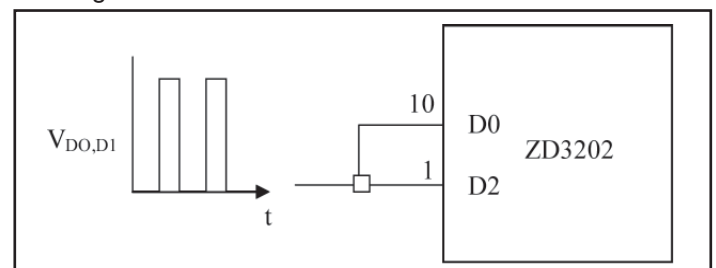
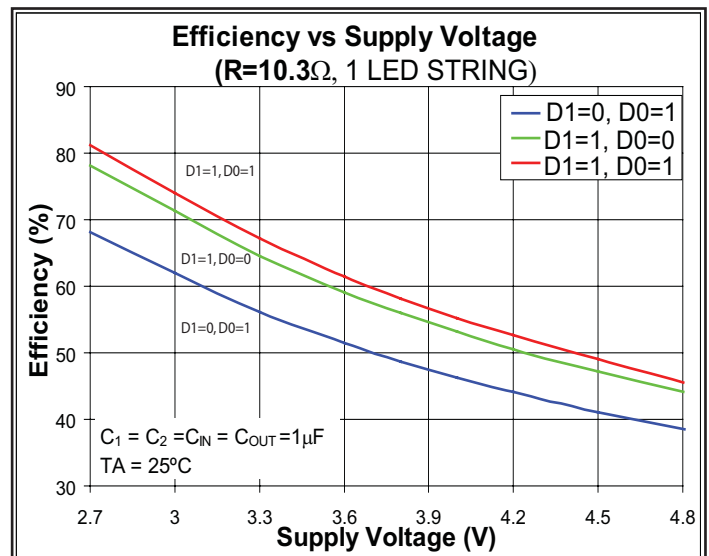
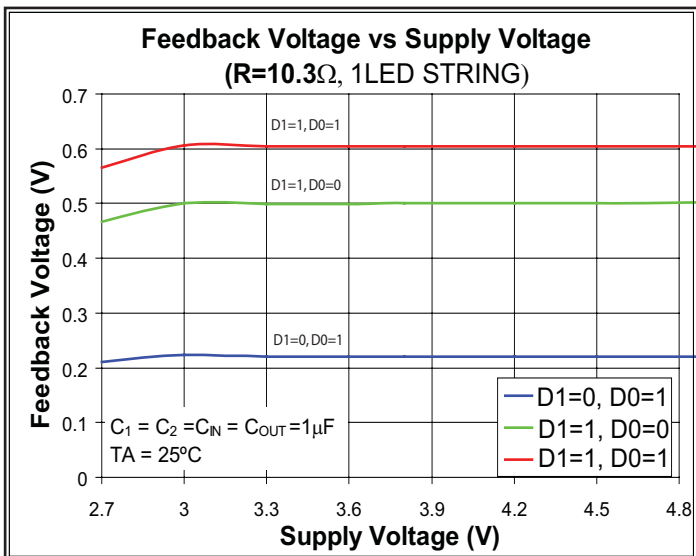
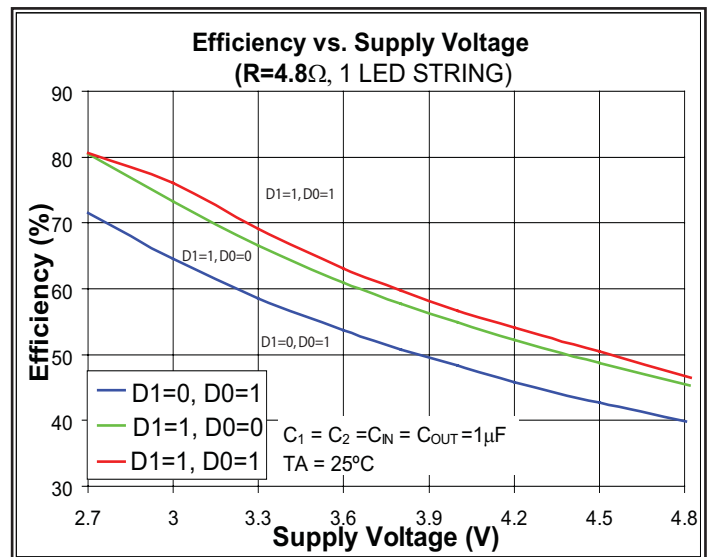
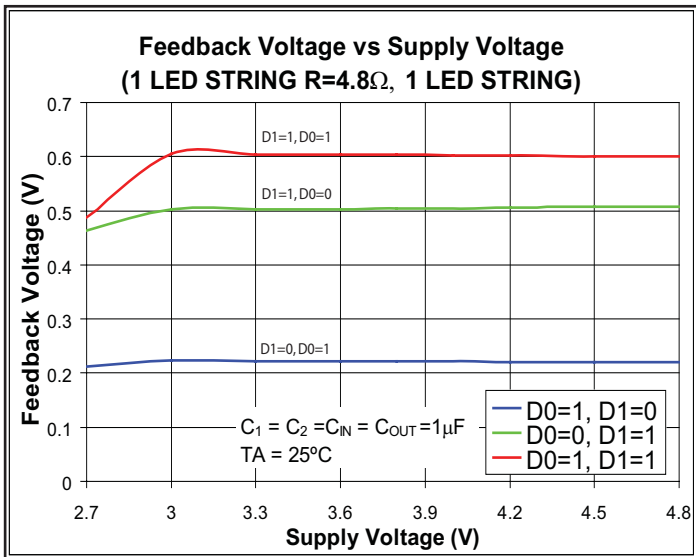
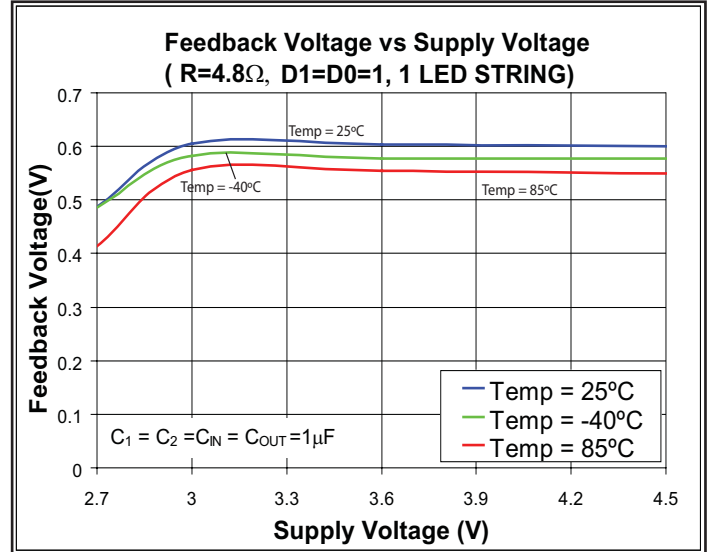
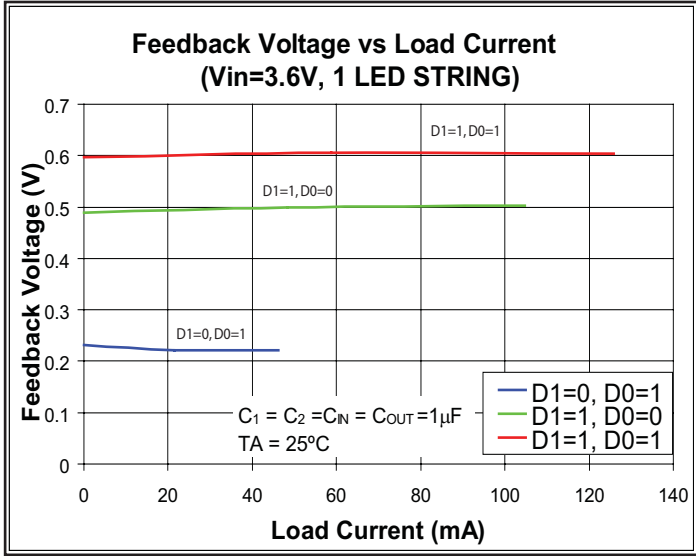


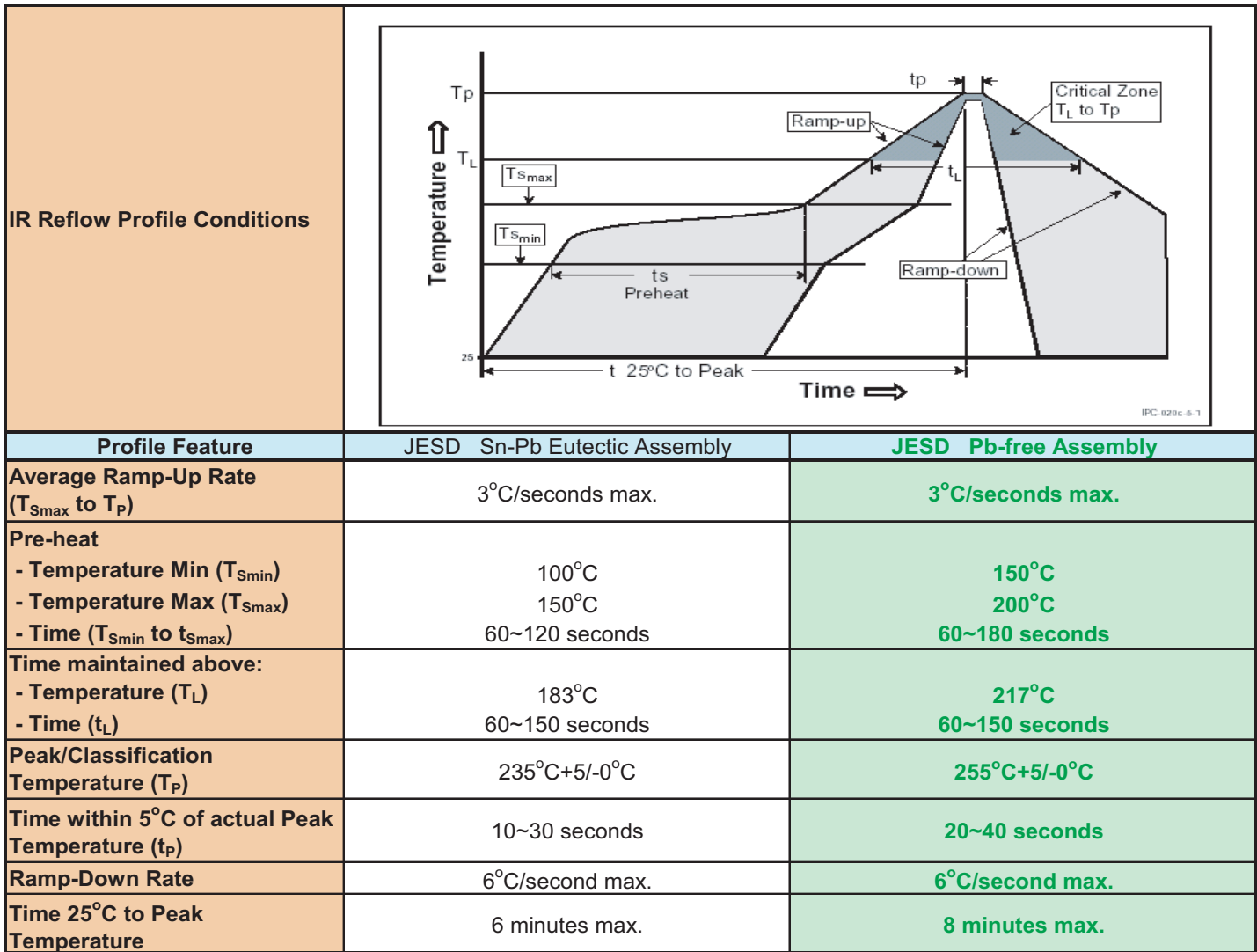
Figure 6. Alternative Brightness Control

Specifications subject to change without notice

Typical Performance Characteristics

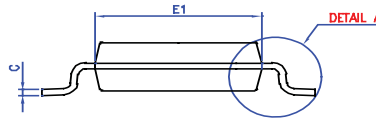
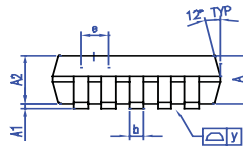
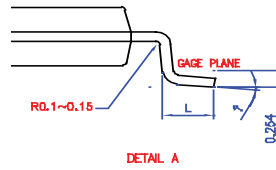
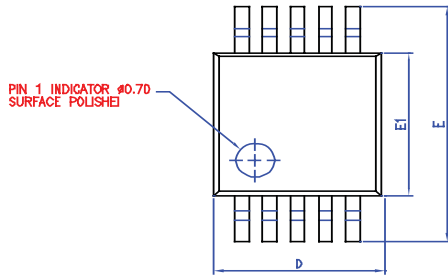


Green Package SMD IR Reflow Profile Information



Zywyn Green Packages are Pb-free and RoHS compliance.

Package Description



NOTE :

1. CONTROLLING DIMENSION : mm
2. LEAD FRAME MATERIAL : OLIN C7025
3. DIMENSION "D" DOES NOT INCLUDE MOLD FLASH, TIE BAR BURRS AND GATE BURRS. MOLD FLASH, TIE BAR BURRS AND GATE BURRS SHALL NOT EXCEED 0.008*[0.15mm] PER END. DIMENSION "E1" DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010*[0.25mm] PER SIDE.
4. DIMENSION "b" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.003*[0.08mm] TOTAL IN EXCEED OF THE "b" DIMENSION AT MAXIMUM MATERIAL CONDITION. DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OR THE FOOT. MINIMUM SPACE BETWEEN PROTRUSION AND AN ADJACENT LEAD TO BE 0.0028*[0.07mm].
5. TOLERANCE : ±0.010*[0.25mm] UNLESS OTHERWISE SPECIFIED.
6. OTHERWISE DIMENSION FOLLOW ACCEPTABLE SPEC.

SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.81	1.02	1.22	0.032	0.040	0.048
△ A1	0.05	—	0.15	0.002	—	0.006
A2	0.76	0.86	0.97	0.030	0.034	0.038
b	0.15	0.20	0.26	0.0059	0.0078	0.0098
c	0.13	0.15	0.23	0.005	0.006	0.009
D	2.90	3.00	3.10	0.114	0.118	0.122
E	4.80	4.90	5.00	0.189	0.193	0.197
E1	2.90	3.00	3.10	0.114	0.118	0.122
e	—	0.50	—	—	0.0196	—
L	0.40	0.53	0.66	0.016	0.021	0.026
△ y	—	—	0.076	—	—	0.003
Ø	0"	3"	6"	0"	3"	6"

10-Lead Plastic MSOP

CUSTOMER :		ZYWYN CORPORATION	
APPROVED BY	DATE	TITLE:	
DRAW BY: <i>Yi-Chen</i>	0/21/00	10L MSOP PACKAGE OUTLINE DRAWING	
CHECK BY: <i>Bill Wang</i>	0/20/00	DWG. NO.	PO-MSOP-003
APPROVAL: <i>Paul Lee</i>	0/20/00	REV.	1
APPROVAL: <i>Jack Tsai</i>	0/20/00	UNIT :	mm
		SCALE :	12/1
		SHEET :	1 OF 1

Evaluation Board



Please contact the factory for White LED driver design support and availability of custom-made evaluation demo boards.

Part Marking Information

TOPSIDE MARK INSTRUCTIONS:

Line 1: Zywyn Part Number "ZD32"
 Line 2: Zywyn Part Number "02LU"

Note: Pin # 1 "△" Indicator Required if no Mold Dimple

BOTTOMSIDE MARK INSTRUCTIONS:

Line 1: Lot Number: XXXXXXXX (Mark only the 4 characters underlined)
 Line 2: Date Code: (Last 2 digits of Prod. Year & Prod. Work Week)

Zywyn Corporation

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