MICROCHIP

MIC2298

3.5A Minimum, 1 MHz Boost High Brightness White LED Driver

Features

- 3.5A Minimum Switch Current Delivers at Least 7W of Output Power Over-Temperature
- 200 mV ±10% Feedback Voltage
- 2.5V to 10V Input Voltage
- Output Voltage up to 30V (Max)
- 12-Lead 3 mm × 3 mm Leadless VDFN Package
- Available Output Over-Voltage Protection (OVP)
- 1 MHz Operation
- Programmable Output Current
- <1% Line Regulation
- 1 µA Shutdown Current
- Over Temperature Protection
- Externally Programmable Soft-Start
- Under-Voltage Lockout (UVLO)
- –40°C to +125°C Junction Temperature Range

Applications

- Cell phones
- PDAs
- Digital cameras
- White LED flashlights

General Description

The MIC2298 is a high power boost-switching regulator that is optimized for constant-current control. The MIC2298 is capable of driving up to 2 series 1A white LED for photoflash, flashlight, and other applications. The feedback voltage is only 200 mV, minimizing ballast power dissipation in constant-current control applications for improved operating efficiency.

The MIC2298 has a brightness pin that allows for a programmable torch mode as well full flash with a single pin when driving high current LEDs.

The MIC2298 implements a constant frequency 1 MHz PWM control scheme to make the smallest possible design.

The 2.5V to 10V input voltage range of MIC2298 allows direct operation from 1- and 2-cell Li Ion as well as 3- to 6-cell NiCad/NiMH/Alkaline battery sources. Maximum battery life is assured with a low 1 µA shutdown current.

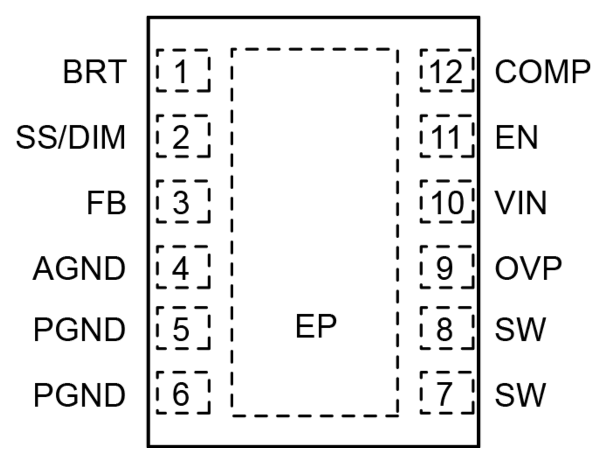
The MIC2298 is available in a low profile 12-lead 3 mm × 3 mm VDFN package.

Package Types

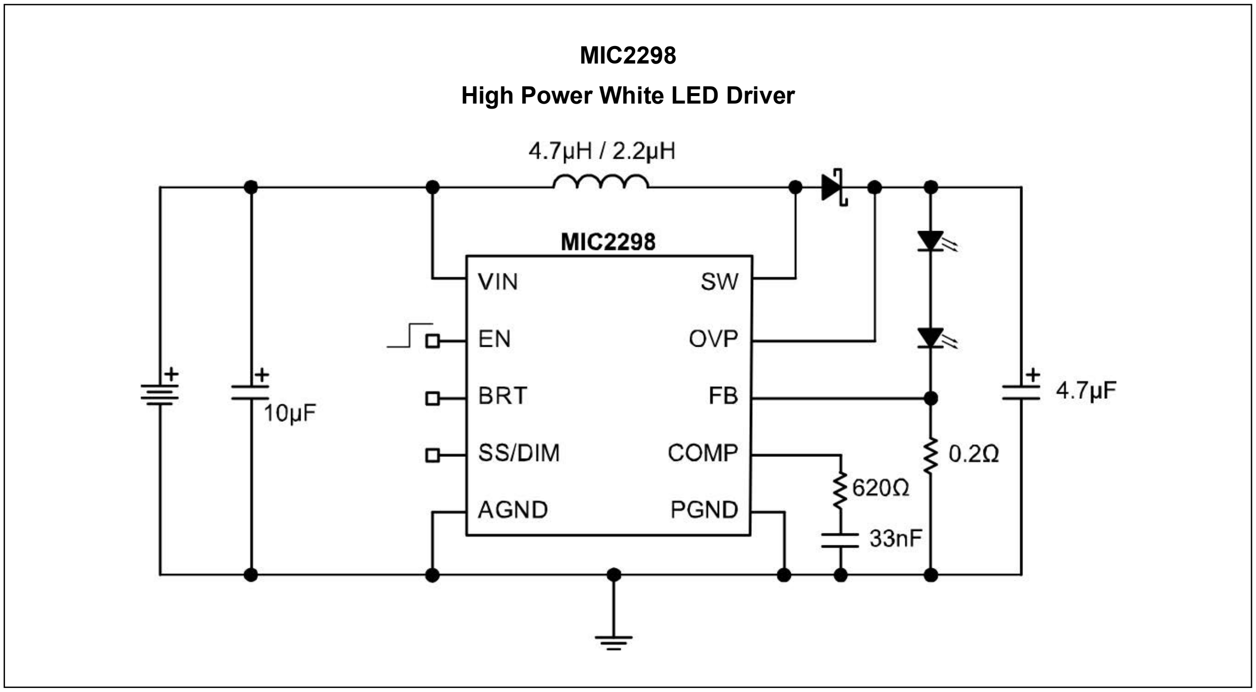
MIC2298

3 mm × 3 mm 12-Lead VDFN

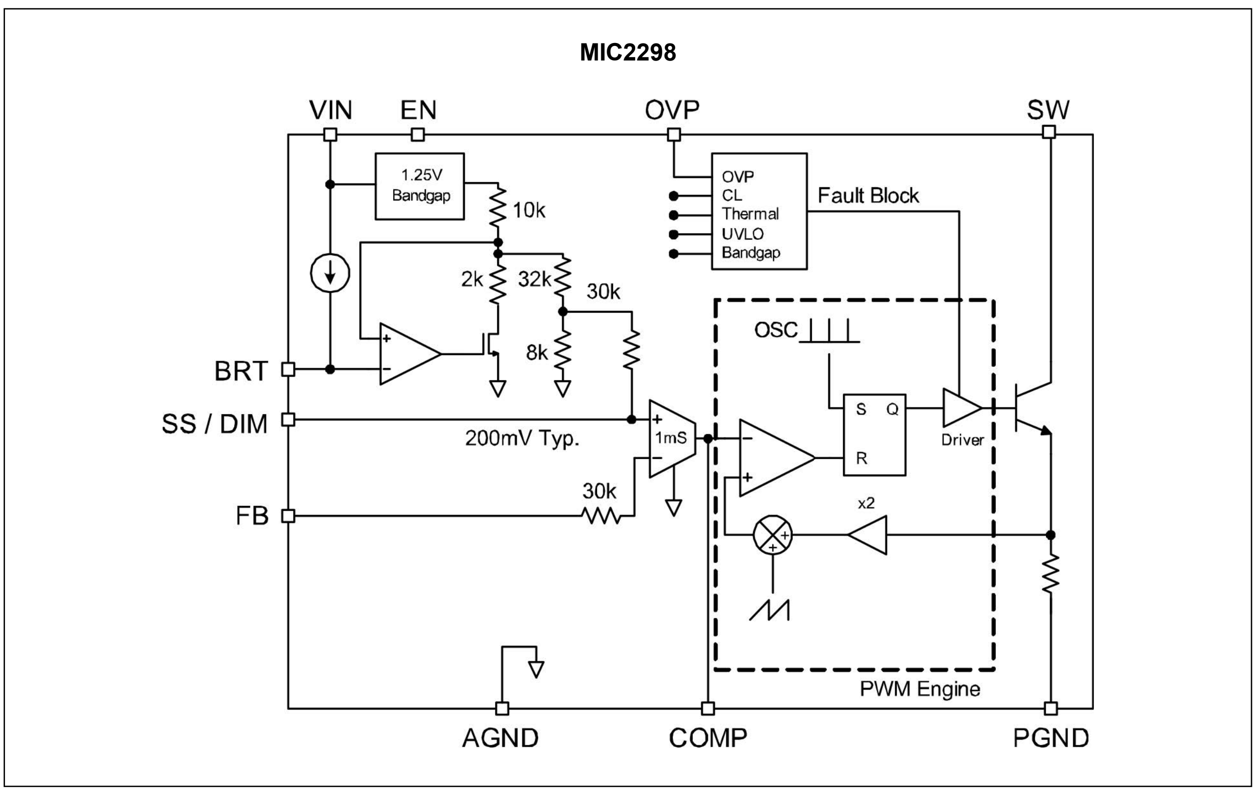
(Top View)



Typical Application Circuit



Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN}) 12V
Switch Voltage (V_{SW}) ....–0.3V to 34V
BRT Voltage (V_{BRT}) ....–0.3V to 6V
SS/DIM Voltage (V_{SS}) ....–0.3V to 6V
Enable Voltage (V_{EN}) ....–0.3V to 12V
FB Voltage (V_{FB}) 6V
Switch Current (I_{SW}) 6A
ESD Rating (Note 1) 2kV

Operating Ratings ‡

Supply Voltage (V_{IN}) ....2.5V to 10V
BRT Voltage (V_{BRT}) ....0V to 0.6 V_{IN}
Enable Voltage (V_{EN}) ....0V to V_{IN}
Output Voltage (V_{OUT}) ....V_{IN} + 1 to V_{OVP}

† Notice: Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

‡ Notice: The device is not guaranteed to function outside its operating ratings.

Note 1: Devices are ESD sensitive. Handling precautions recommended..

ELECTRICAL CHARACTERISTICS (Note 1)

T_A = 25°C; V_{IN} = V_{EN} = 3.6V; V_{OUT} = 7V; I_{OUT} = 1A, unless otherwise noted. **Bold** values indicate –40°C < T_J < +125°C.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Supply Voltage Range	V_{IN}	2.5	—	10	V	—
Under-voltage Lockout	V_{UVLO}	1.8	2.1	2.4	V	—
Over-voltage Protection	V_{OVP}	12	13.5	15	V	—
Quiescent Current	I_{VIN}	—	15	23	mA	V_{FB} >200 mV, Not Switching
Shutdown Current	I_{SD}	—	0.1	1	µA	V_{EN} = 0V (Note 2)
Feedback Voltage	V_{FB}	184	200	216	mV	(±8%)
		180	—	**220**		(±10%) (Over Temp)
Feedback Input Curent	I_{FB}	—	−650	—	nA	V_{FB} = 200 mV
Line Regulation		—	0.5	—	%	2.5V ≤ V_{IN} ≤ 4.5V
BRT Accuracy (Note 3)	I_{LED}	**17**	20	**23**	%	R_{BRT} = GND
		45	50	**55**		R_{BRT} = 50K
Maximum Duty Cycle	D_{MAX}	**85**	90	—	%	—
Switch Current Limit	I_{SW}	**3.5**	4.75	**8**	A	V_{IN} = 3V
Switch Saturation Voltage	V_{SW}	—	350	500	mV	V_{IN} = 3.6V, I_{SW} = 3.5A

Note 1: Specification for packaged product only.
2: I_{SD} = I_{VIN}
3: As percentage of full brightness where V_{IN} = V_{BRT} = 3.6V (100% brightness)

ELECTRICAL CHARACTERISTICS (Note 1) (CONTINUED)

T_A = 25°C; V_{IN} = V_{EN} = 3.6V; V_{OUT} = 7V; I_{OUT} = 1A, unless otherwise noted. **Bold** values indicate –40°C < T_J < +125°C.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Switch Leakage Current	I_{SW}	—	0.01	**10**	µA	V_{EN} = 0V, V_{SW} = 15V
Enable Threshold	V_{EN}	**1.5**	—	—	V	Turn On
		—	—	**0.4**		Turn Off
Enable Pin Current	I_{EN}	—	20	40	µA	V_{EN} = 10V
Oscillator Frequency	f_{SW}	0.8	1	1.2	MHz	—
Soft Start (SS) / DIM Current	I_{SS}	—	5	—	µA	DIM = 0V
Overtemperature Threshold Shutdown	T_J	—	150	—	°C	—
		—	10	—	°C	Hysteresis

Note 1: Specification for packaged product only.

2: I_{SD} = I_{VIN}

3: As percentage of full brightness where V_{IN} = V_{BRT} = 3.6V (100% brightness)

TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Operating Junction Temperature Range	T_J	–40	—	+125	°C	—
Ambient Storage Temperature Range	T_S	–65	—	+150	°C	—
Thermal Resistance: 12-Lead 3 mm × 3 mm VDFN	θ_{JA}	—	+60	—	°C/W	—

2.0 TYPICAL PERFORMANCE CURVES

Note:	The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

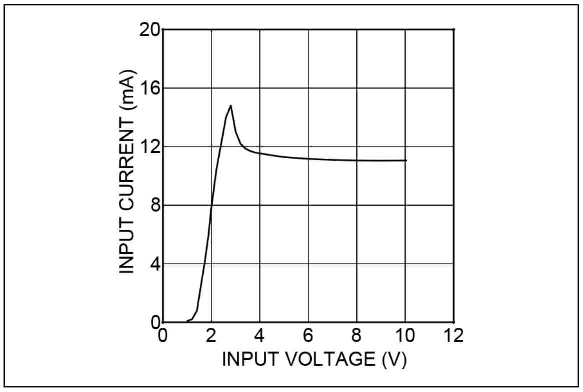


FIGURE 2-1: *Input Current vs. Input Voltage.*

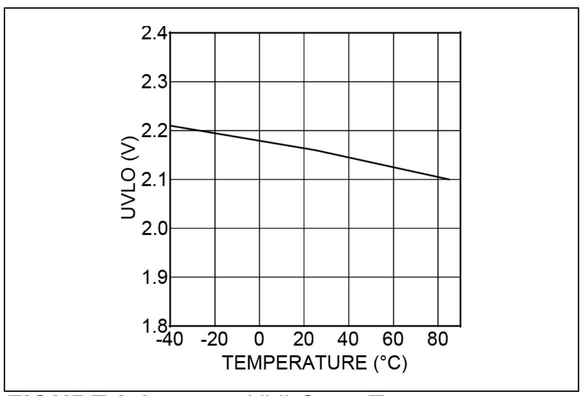


FIGURE 2-2: *UVLO vs. Temperature.*

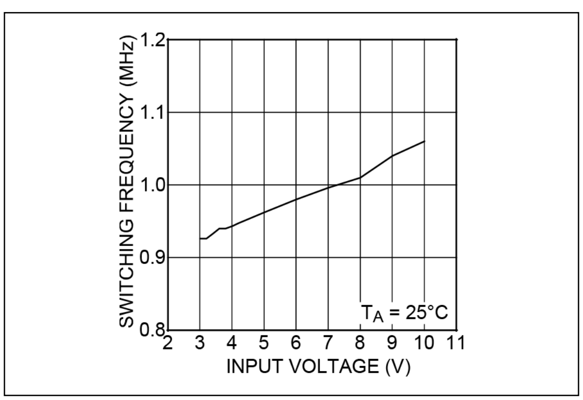


FIGURE 2-3: *Switching Frequency vs. Input Voltage.*

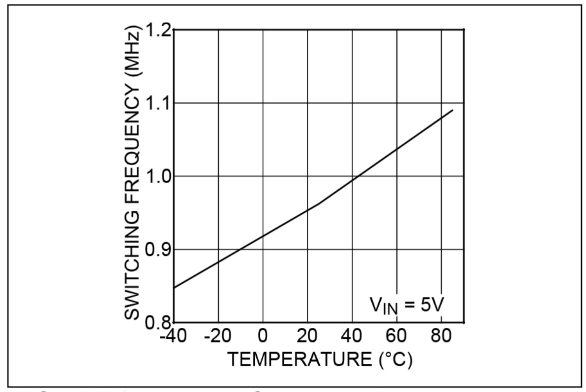


FIGURE 2-4: *Switching Frequency vs. Temperature.*

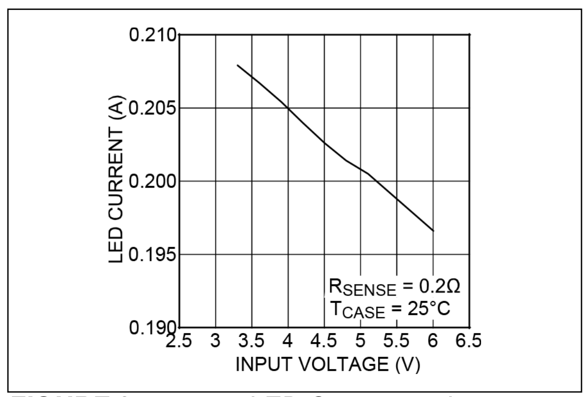


FIGURE 2-5: *LED Current vs. Input Voltage (BRT GND).*

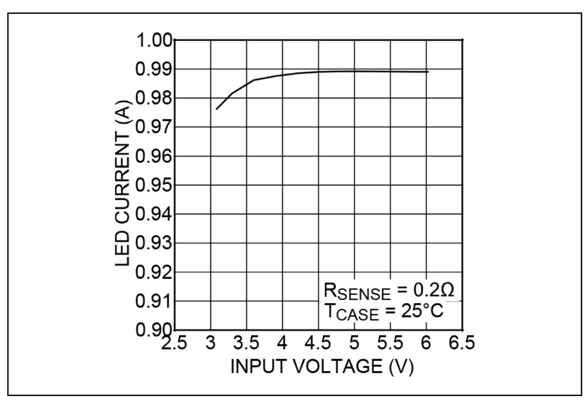


FIGURE 2-6: *LED Current vs. Input Voltage (BRT Open).*

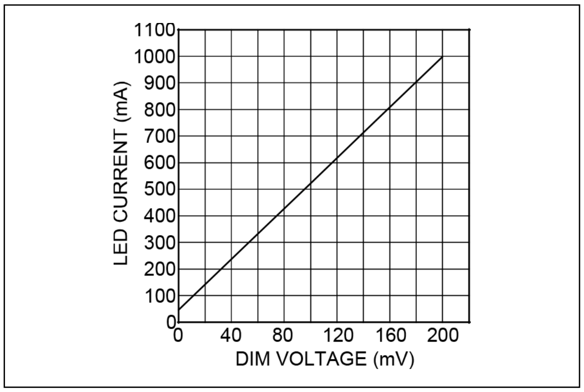


FIGURE 2-7: *LED Current vs. SS/DIM Voltage.*

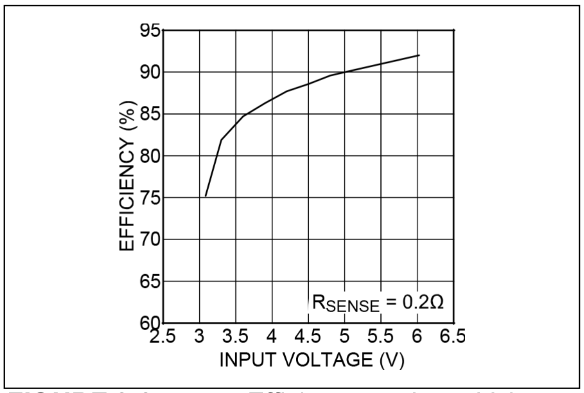


FIGURE 2-8: *Efficiency vs. Input Voltage (BRT Open).*

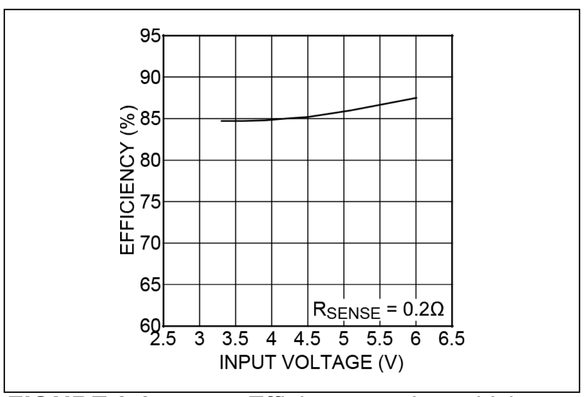


FIGURE 2-9: *Efficiency vs. Input Voltage (BRT GND).*

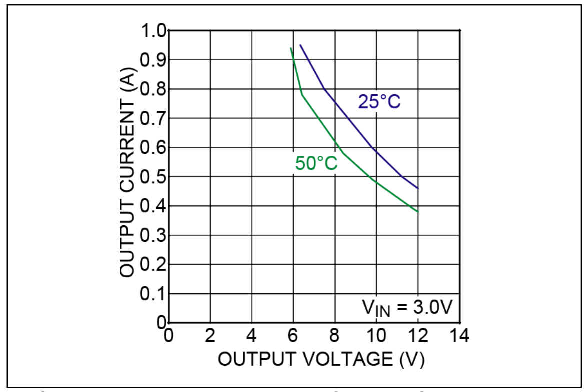


FIGURE 2-10: *Max DC LED Current vs. Output Voltage.*

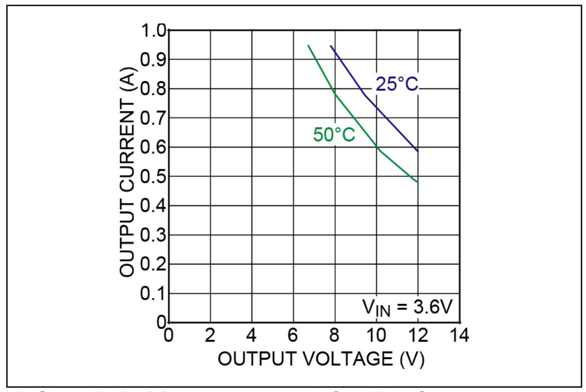


FIGURE 2-11: *Max DC LED Current vs. Output Voltage.*

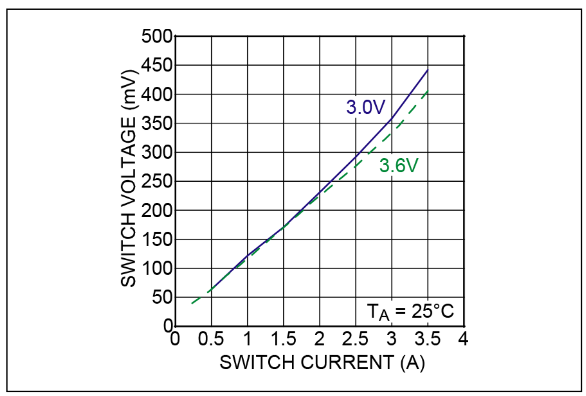


FIGURE 2-12: *Bipolar Saturation Voltage vs. Switch Current.*

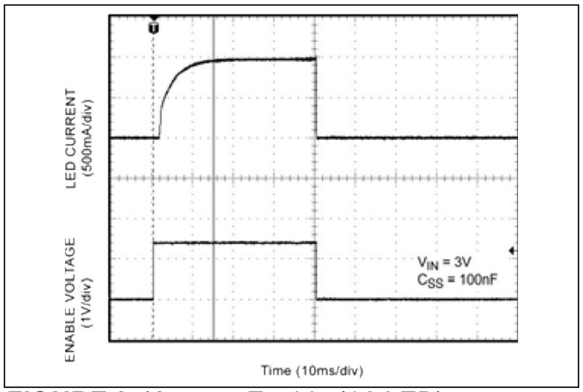


FIGURE 2-13: *Enable (1A LED).*

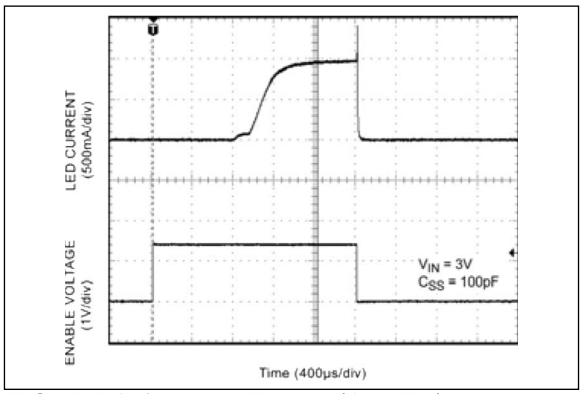


FIGURE 2-14: *Enable (1A LED).*

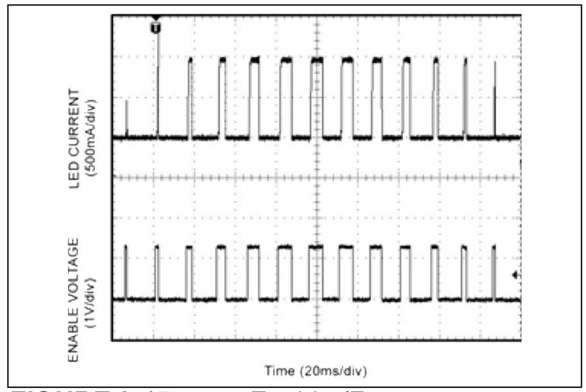


FIGURE 2-15: *Enable (Frequency = 67 Hz).*

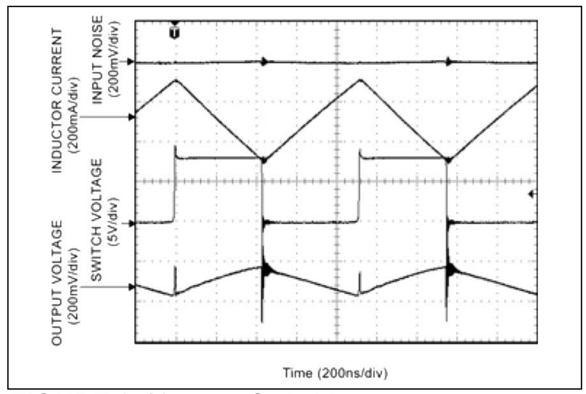


FIGURE 2-16: *Switching.*

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

Pin Number	Pin Name	Description
1	BRT	BRT (input): Apply a voltage greater than or equal to 1V to achieve full brightness current as determined by the ballast resistor. A 10 µA current source sets the voltage on the resistor. Hence a 50K resistor would yield 0.5V, which causes a reduction in LED current to 50% of full brightness. Grounding the BRT reduces the current further to 20% of full brightness. This pin may also be driven by a PWM signal for the same effect.
2	SS/DIM	Soft start/dimming (input) 40 kΩ source. Connect a capacitor to GND for soft start. Clamp the pin to a known voltage to control the internal reference voltage and hence the output current. This can also be done with a resistor to GND.
3	FB	Feedback (Input): Output voltage sense node. Connect the cathode of the LED to this pin.
4	AGND	Analog Ground.
5, 6	PGND	Power Ground.
7, 8	SW	Switch Node: Internal power BIPOLAR collector.
9	OVP	Over-Voltage Protection (OVP): Connect to the output voltage to clamp the maximum output voltage. A resistor divider from this pin to ground could be used to raise the OVP level beyond 15V (max).
10	VIN	Supply (Input): 2.5V to 10V for internal circuitry.
11	EN	Enable (Input): Applying 1.5V or greater enables the regulator. Applying a voltage of 0.4V or less disables the MIC2298.
12	COMP	Compensation pin (input): Add external R and C to GND to stabilize the converter.
Pad	EP	Ground (Return): Backside exposed pad.

4.0 FUNCTIONAL DESCRIPTION

The MIC2298 is a constant frequency, pulse-width modulated (PWM) peak current-mode step-up regulator. The MIC2298 simplified control scheme is illustrated in the Functional Block Diagram. A reference voltage is fed into the PWM engine, where the duty cycle output of the constant frequency PWM engine is computed from the error, or difference, between the REF and FB voltages.

The PWM engine encompasses the necessary circuit blocks to implement a current-mode boost switch-mode power supply. The necessary circuit blocks include, but are not limited to, a oscillator/ramp generator, slope compensation ramp generator, gm error amplifier, current amplifier, PWM comparator, and drive logic for the internal 3.5A bipolar power transistor.

Inside the PWM engine, the oscillator functions as a trigger for the PWM comparator that turns on the bipolar power transistor and resets the slope compensation ramp generator.

The current amplifier is used to measure the power transistor's current by amplifying the voltage signal from the CS+ and CS- inputs from the sense resistor connected to the emitter of the bipolar power transistor. The output of the current amplifier is summed with the output of the slope compensation ramp generator where the result is connected to one of the inputs of the PWM comparator.

The gm error amplifier measures the white LED current through the external sense resistor and amplifies the error between the detected voltage signal from the feedback, or FB pin and the internal reference voltage. The output of the gm error amplifier provides the voltage loop signal that is fed to the other input of the PWM comparator.

When the current loop signal exceeds the voltage loop signal, the PWM comparator turns off the power transistor. The next oscillator or clock period initiates the next switching cycle, maintaining the constant frequency current-mode PWM control. The maximum white LED current is set by the feedback resistor (the resistor connected from the feedback pin to ground):

EQUATION 4-1:

$$I_{LEAK} = \frac{200mV}{R_{FB}}$$

The enable pin shuts down the output switching and disables control circuitry to reduce input current-to-leakage levels. Enable pin input current is zero at zero volts.

4.1 DC-to-DC PWM Boost Conversion

The MIC2298 is a constant-frequency boost converter. It operates by taking a DC input voltage and regulating a DC output voltage. Figure 4-1 shows a typical circuit. Boost regulation is achieved by turning on an internal switch, which draws current through the inductor (L1).

When the switch turns off, the inductor's magnetic field collapses. This causes the current to be discharged into the output capacitor through an external Schottky diode (D1). Figure 2-16 shows Input Voltage ripple, Output Voltage ripple, SW Voltage, and Inductor Current for 900 mA LED current. Regulation is achieved by modulating the pulse width i.e., pulse-width modulation (PWM).

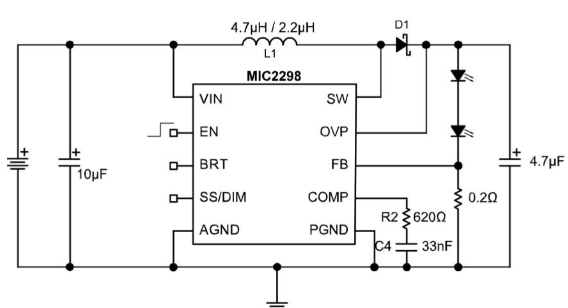


FIGURE 4-1: Typical Application Circuit.

4.2 Duty Cycle Considerations

Duty cycle refers to the switch on-to-off time ratio and can be calculated as follows for a boost regulator:

EQUATION 4-2:

$$D = 1 - \frac{V_{IN}}{V_{OUT}}$$

However, at light loads, the inductor will completely discharge before the end of a switching cycle. The current in the inductor reaches 0A before the end of the switching cycle. This is known as discontinuous conduction mode (DCM). DCM occurs when:

EQUATION 4-3:

$$I < \frac{V_{IN}}{V_{OUT}} \times \frac{I_{PEAK}}{2}$$

Where:

EQUATION 4-4:

$$I_{PEAK} = \frac{(V_{OUT} - V_{IN})}{L \times f} \times \left(\frac{V_{IN}}{V_{OUT}}\right)$$

In DCM, the duty cycle is smaller than in continuous conduction mode. In DCM, the duty cycle is given by:

EQUATION 4-5:

$$D = \frac{f \times \sqrt{2 \times L \times I_{OUT} \times (V_{OUT} - V_{IN})}}{V_{IN}}$$

The duty cycle required for voltage conversion should be less than the maximum duty cycle of 95%. Also, in light load conditions where the input voltage is close to the output voltage, the minimum duty cycle can cause pulse skipping. This is due to the energy stored in the inductor causing the output to slightly overshoot the regulated output voltage.

During the next cycle, the error amplifier detects the output as being high and skips the following pulse. This effect can be reduced by increasing the minimum load or by increasing the inductor value. Increasing the inductor value also reduces the peak current.

4.3 Over-Voltage Protection

The MIC2298 offers over-voltage protection functionality. If an LED is disconnected from the circuit or the feedback pin is shorted to ground, the feedback pin will fall to ground potential. This will cause the MIC2298 to switch at full duty cycle in an attempt to maintain the feedback voltage. As a result, the output voltage will climb out of control.

This may cause the switch node voltage to exceed its maximum voltage rating, possibly damaging the IC and the external components. To ensure the highest level of protection, the MIC2298 OVP pin will shut the switch off when an over-voltage condition is detected, saving itself and the output capacitor from damage.

The OVP threshold can be increased by adding a resistor divider between the output and ground. Be careful not to exceed the 30V rating of the switch.

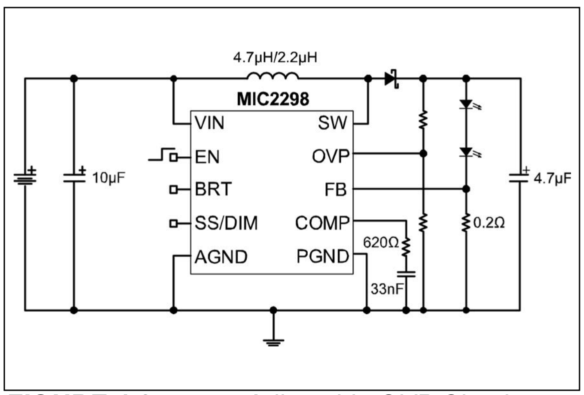


FIGURE 4-2: *Adjustable OVP Circuit.*

4.4 Brightness Control

TABLE 4-1: BRT PIN BRIGHTNESS FUNCTIONALITY

BRT Pin	V_{FB} (V)
OPEN	200 mV or $V_{SS/DIM}$
GND	40 mV
≥20 kΩ to 100 kΩ [R_{BRT}] to GND	(10 µA × R_{BRT})/5

TABLE 4-2: SS/DIM PIN BRIGHTNESS FUNCTIONALITY

SS/DIM	V_{FB} (V)
OPEN	200 mV
Voltage v	V_{FB} = v

The MIC2298 has built in brightness/dimming functionally for white LED applications. The BRT and SS/DIM pins are available for brightness/dimming control functionality. Table 4-1 and Table 4-2 illustrate the different modes of dimming functionality afforded by the BRT and SS/DIM pins. The resulting LED current is then calculated as:

EQUATION 4-6:

$$I_{LED} = \frac{V_{FB}}{R_{SENSE}}$$

Hence, a 200 mΩ sense resistor will achieve nominally 1A when both SS/DIM and BRT pins are left open.

4.5 PWM Control of Brightness

A control signal can be driven into the enable pin to vary average current through the LED for applications not sensitive to low frequency (~100 Hz) light modulation.

For such applications, the SS/DIM pin capacitance should be minimized to achieve a fast turn on time. 0 nF will achieve approximately 1.5 ms with a C_{COMP} value of 33 nF.

For other applications, where no analog control voltage is available, the BRT pin can be driven through a low pass filter (18 kΩ and 470 nF) at a PWM frequency of >5kHz to set the FB voltage, and therefore, the LED current from 20% to 100% of Nominal LED current (Figure 4-3).

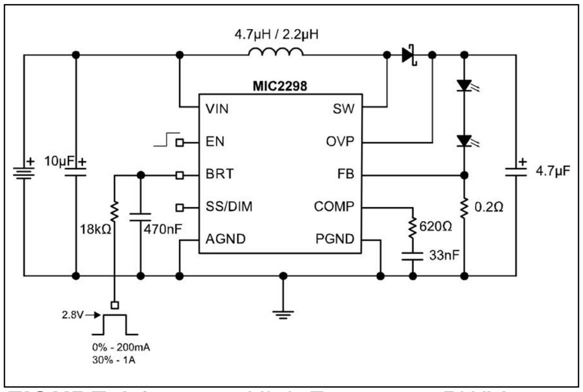


FIGURE 4-3: High Frequency PWM Programming via BRT Pin.

Since the SS/DIM pin is typically utilized for soft start, it is recommended to use the enable and BRT pins for the PWM method of adjusting the average LED current. Figure 4-4 and Figure 4-5 show typical results for this method.

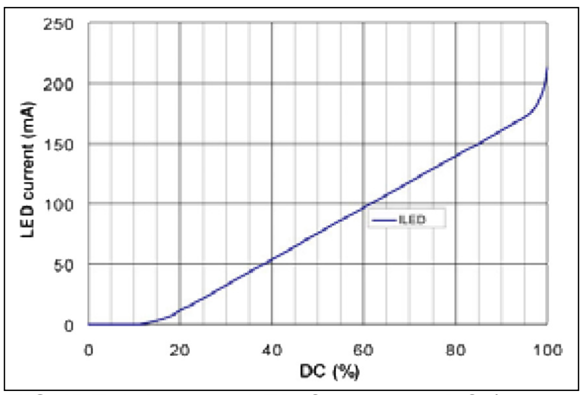


FIGURE 4-4: LED Current vs. DC (on Enable Pin).

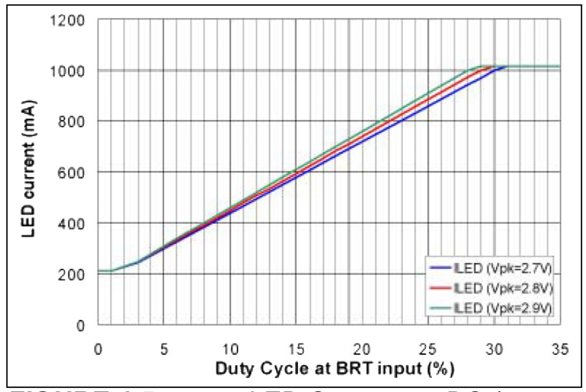


FIGURE 4-5: LED Current vs. DC (on BRT Pin).

Should the SS/DIM pin be used for voltage programming the LED current, note that there will be a small offset due mismatches between the 30k FB input and the impedance driving the SS/DIM pin.

4.6 Soft Start Functionality

The soft start time is dependent up on both CSS and the comp capacitor values. C_{COMP} is fixed for stable operation (typically 33 nF); therefore, if any increases in soft start are desired, this should be done using the CSS capacitor. The approximate total startup time is given by the larger of:

EQUATION 4-7:

$$T_{SS} = 1ms + 175k \times C_{SS}$$

Or:

EQUATION 4-8:

$$T_{SS} = 1ms + C_{COMP} \div 44 \times 10^{-6}$$

For example: For C_{COMP} = 33 nF, use values of C_{COMP} > 4.3 nF to increase startup time from 1.75 ms. The soft start capacitor should be connected from the SS/DIM pin to ground.

5.0 COMPONENT SELECTION

5.1 Inductor

Inductor selection is a balance between efficiency, stability, cost, size, and rated current. For most applications, a 4.7 µH is the recommended inductor value. It is usually a good balance between these considerations. Larger inductance values reduce the peak-to-peak ripple current, affecting efficiency.

This has the effect of reducing both the DC losses and the transition losses. There is also a secondary effect of an inductor's DC resistance (DCR). The DCR of an inductor will be higher for more inductance in the same package size. This is due to the longer windings required for an increase in inductance.

Since the majority of input current (minus the MIC2298 operating current) is passed through the inductor, higher DCR inductors will reduce efficiency. To maintain stability, increasing inductor size will have to be met with an increase in output capacitance. This is due to the unavoidable "right half plane zero" effect for the continuous current boost converter topology.

The frequency at which the right half plane zero occurs can be calculated as follows:

EQUATION 5-1:

$$f_{rhpz} = \frac{(V_{IN})^2}{V_{OUT} \times L \times I_{OUT} \times 2\pi}$$

The right half plane zero has the undesirable effect of increasing gain, while decreasing phase. This requires that the loop gain is rolled off before this has significant effect on the total loop response. This can be accomplished by either reducing inductance (increasing RHPZ frequency) or increasing the output capacitor value (decreasing loop gain).

5.2 Output Capacitor

Output capacitor selection is also a trade-off between performance, size, and cost. Increasing output capacitance will lead to an improved transient response, but also an increase in size and cost. X5R or X7R dielectric ceramic capacitors are recommended for designs with the MIC2298.

The output capacitor sets the frequency of the dominant pole and zero in the power stage. The zero is given by:

EQUATION 5-2:

$$f_z = \frac{1}{C \cdot R_{esr} \times 2\pi}$$

For ceramic capacitors, the ESR is very small. This puts the zero at a very high frequency where it can be ignored. Fortunately, the MIC2298 is current mode in operation which reduces the need for this output capacitor zero when compensating the feedback loop.

The frequency of the pole caused by the output capacitor is given by.

EQUATION 5-3:

$$f_p = \frac{I_{OUT}}{C \times V_{OUT} \times 2 \times \pi}$$

5.3 Diode Selection

The MIC2298 requires an external diode for operation. A Schottky diode is recommended for most applications due to their lower forward voltage drop and reverse recovery time. Ensure the diode selected can deliver the peak inductor current and the maximum reverse voltage is rated greater than the output voltage.

5.4 Input Capacitor

A minimum 1 µF ceramic capacitor with an X5R or X7R dielectric is recommended for designing with the MIC2298. Increasing input capacitance will improve performance and greater noise immunity on the source.

The input capacitor should be as close as possible to the inductor and the MIC2298, with short traces for good noise performance.

The MIC2298 utilizes a feedback pin to compare the LED current to an internal reference. The LED current is adjusted by selecting the appropriate feedback resistor value. The desired output current can be calculated as follows:

EQUATION 5-4:

$$I_{LED} = \frac{0.2V}{R}$$

5.5 Compensation

The comp pin is connected to the output of the voltage error amplifier. The voltage error amplifier is a transconductance amplifier. Adding a series RC-to-ground adds a zero at:

EQUATION 5-5:

$$f_{ZERO} = \frac{1}{2\pi R_2 C_4}$$

The resistor typically ranges from 1 kΩ to 50 kΩ. The capacitor typically ranges from 1 nF to 100 nF.

Adding an optional capacitor from comp pin-to-ground adds a pole at approximately:

EQUATION 5-6:

$$f_{pole} = \frac{1}{2\pi R_2 C_3}$$

This capacitor typically ranges from 100 pF to 10 nF. Generally, an RC to ground is all that is needed. The RC should be placed as close as possible to the compensation pin. The capacitor should be a ceramic with a X5R, X7R, or COG dielectric. Refer to the MIC2298 evaluation board document for component location.

6.0 APPLICATION INFORMATION

6.1 Grounding

Both the AGND and PGND pins must be connected to the exposed backside pad. The exposed backside pad also improves thermal performance. A large ground plane decreases thermal resistance to ambient air.

6.2 Thermal Considerations and the SOA

The SOA (safe operating area) of the MIC2298 is shown in the typical characteristics sub-section. This graph represents the maximum continuous output power capability of the part when used in the evaluation board layout. An alternative layout with more copper area for heat sinking will increase the area under the SOA curve.

Note that the SOA is for continuous power and not peak power and is effectively a thermal limitation. The SOA is true for a time constant of approximately >1 second.

Therefore, any load transient with a period of < 3s can exceed the SOA curve power up to a maximum limited by the current limit of the MIC2298. Figure 6-1 shows the theoretical output current limit of the MIC2298 using the Evaluation Board inductor value of 4.7 µH.

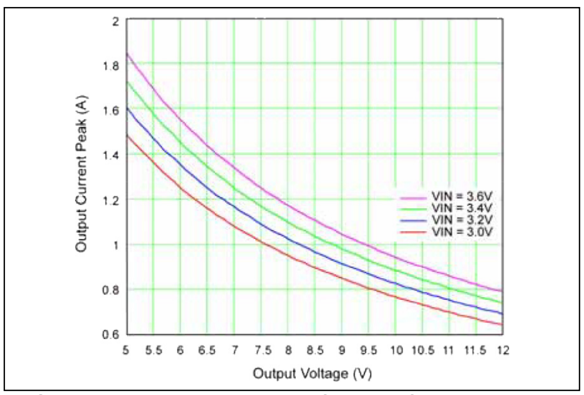


FIGURE 6-1: *Peak Output Current vs. V_{OUT}.*

If our load is within these limits, it is possible to drive the load at some repetition rate or duty cycle (DC). This is allowed as long as we limit the RMS current to below the SOA limit.

The RMS current for a pulsed current is known to be:

EQUATION 6-1:

$$I_{RMS} = (I_{PK-PK} \times \sqrt{DC}) + I_{DC}$$

Where the current pulse I_{PK-PK} sits on a DC level of I_{DC}. This simplifies to the following when there is no DC level:

$$I_{RMS} = I_{PK} \times \sqrt{DC}$$

The graph in Figure 6-2 shows the peak LED current which can be pulsed at a given duty cycle (DC) to stay within SOA limits of 400 mA to 700 mA.

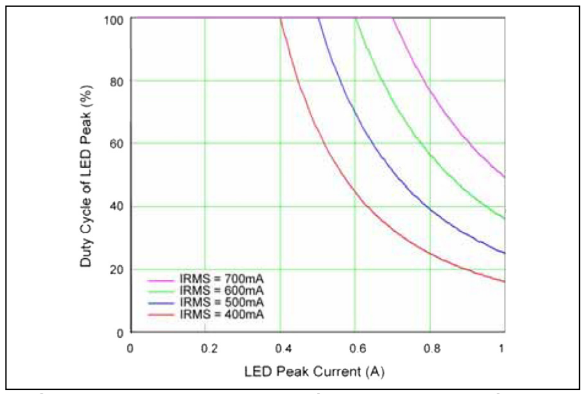


FIGURE 6-2: *Duty Cycle vs. Peak Current for Fixed RMS Current.*

EXAMPLE 6-1:

Two high-brightness white LEDs connected in series with a $V_{f(MAX)}$ of 4.2V and a peak current of 800 mA require pulses of 300 ms at 3 second intervals. The power source is a Li-ion cell of 3V minimum.

- Looking at the SOA curves in Figure 2-10 and Figure 2-11, these cannot be driven continuously.
- The time constant of the driver is < 3 seconds, so one can look at the peak current capability of the driver in Figure 6-1.
- Looking at Figure 6-1, the MIC2298 can achieve more than the required 800mA peak current at 8.4V.

- Reading from the SOA curve in Figure 2-10, the MIC2298 with V_{IN} = 3V, 50°C, and 8.4V output voltage can provide 580 mA RMS.
- Now looking at the curve in Figure 6-2, using the next lower value of 500 mA RMS current, one can see that the 850 mA peak can be driven at a duty cycle of ~33% (or 1 second out of every 3 seconds). That is well within our target of 300 ms.

6.3 LED Protection

The operation of the Power LED must be limited to short pulses to prevent overheating. This is usually controlled by the micro controller in a typical application. For further protection, or where a micro controller is not used, the temperature of the LED can be limited by the addition of an NTC thermistor.

The value should be > 100 kΩ at its maximum safe temperature. This will then limit current drive to the LED as temperature rises further and prevents overheating. This thermistor should be connected directly from BRT to GND. Reference Figure 6-3.

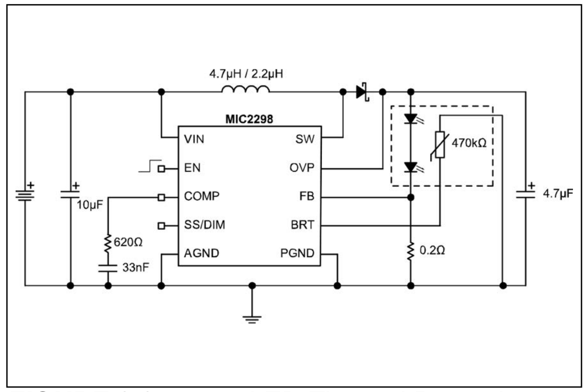


FIGURE 6-3: *LED Thermal Protection.*

7.0 PACKAGING INFORMATION

7.1 Package Marking Information

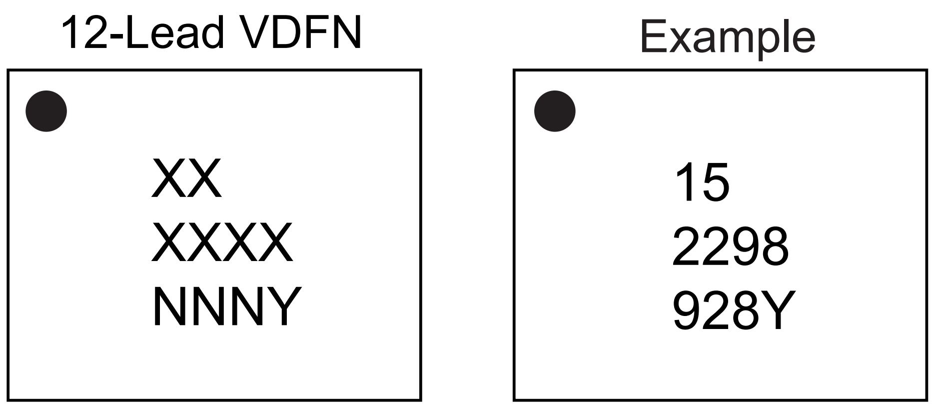


TABLE 7-1: ORDERING INFORMATION

Part Number	OVP	Frequency	Junction Temp. Range	Package	Lead Finish
MIC2298-15YML	15V	1 MHz	–40° to +125°C	12-Lead 3 mm × 3 mm VDFN	Pb-Free

Note: This VDFN is a GREEN RoHS compliant package. Lead finish is NiPdAu. Mold compound is Halogen Free.

PACKAGE MARKING DRAWING SYMBOLS LEGEND

Symbol	Definition
XX . . . X	Product code or customer-specific information. (Note 1, Note 2)
YYWW	Date code, where YY is the last 2 digits of calendar year and WW is the work week (i.e., week of January 1 is week 01). (Note 3)
M	Month of assembly (if applicable). January is represented by “A” and each month thereafter follows the order of the alphabet through “L” for December.
NNN	Alphanumeric traceability code. (Note 3, Note 4)
(e3)	Pb-free JEDEC designator for Matte Tin (Sn).
*	Indicates this package is Pb-free. The Pb-free JEDEC designator (the symbol in the row above this one) can be found on the outer packaging for this package.
●, ▲, ▼	Pin one index is identified by a dot, delta up, or delta down (triangle mark).

Note 1: If the full Microchip part number cannot fit on one line, it will be carried over to the next line, limiting the number of available characters for customer-specific information. The package may or may not include the corporate logo.

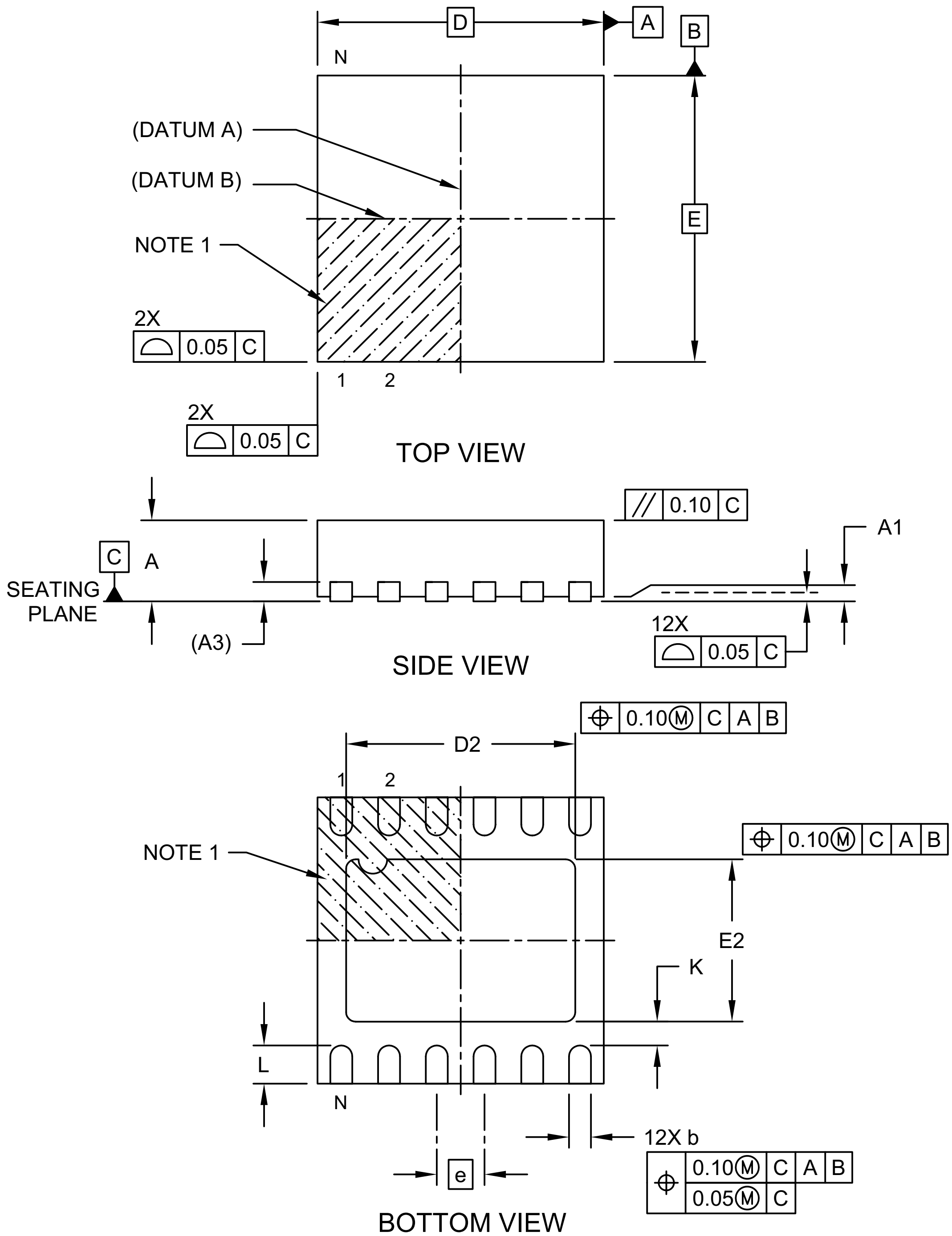
2: Any underbar (_) and/or overbar (‾) symbols shown in a package marking drawing may not be to scale.

3: If the full date code (YYWW) and the alphanumeric traceability code (NNN)—usually marked together on the last or only line of a package marking as the seven-character YYWWNNN—cannot fit on the package together, the codes will be truncated based on the number of available character spaces, as follows:
6 characters = YWWNNN; 5 characters = WWNNN; 4 characters = WNNN; 3 characters = NNN;
2 characters = NN; 1 character = N.

4: Some products might have a “Y” symbol at the end of the last or only line in a package marking, usually at the end of the alphanumeric traceability code (NNN or truncated versions), to indicate the product is Pb-free.

12-Lead 3 mm × 3 mm VDFN [JQA] Package Outline and Recommended Land Pattern

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



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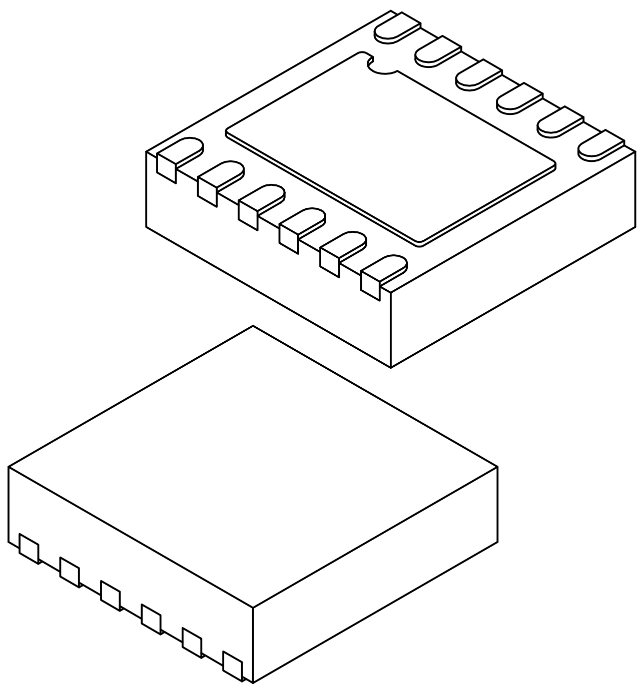
12-Lead 3 mm × 3 mm VDFN [JQA] Package Outline and Recommended Land Pattern

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Terminals	N		12	
Pitch	e		0.50 BSC	
Overall Height	A	0.80	0.85	0.90
Standoff	A1	0.00	0.02	0.05
Terminal Thickness	A3		0.203 REF	
Overall Length	D		3.00 BSC	
Exposed Pad Length	D2	2.35	2.40	2.45
Overall Width	E		3.00 BSC	
Exposed Pad Width	E2	1.65	1.70	1.75
Terminal Width	b	0.18	0.23	0.28
Terminal Length	L	0.35	0.40	0.45
Terminal-to-Exposed-Pad	K	0.20	-	-

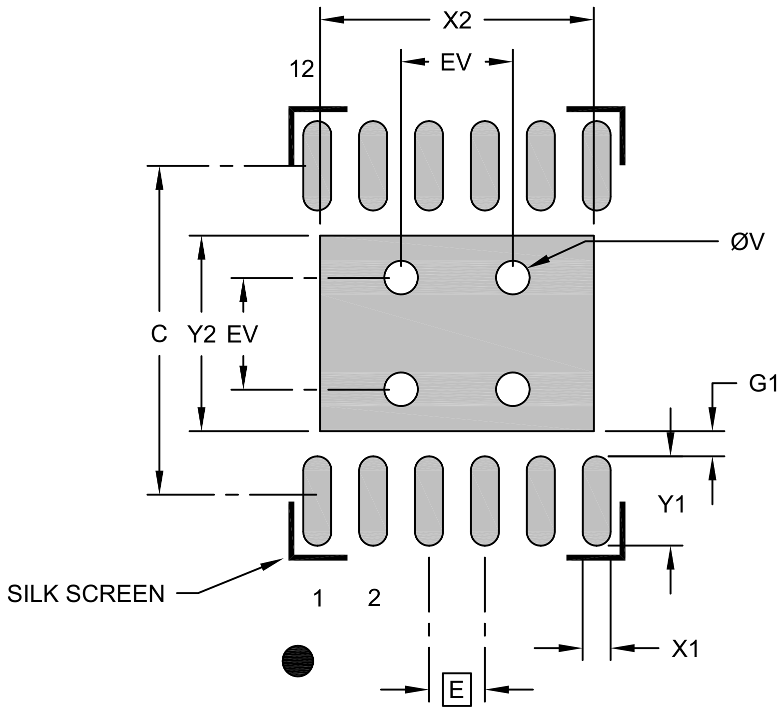
Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package is saw singulated
3. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-1020 Rev. A Sheet 2 of 2

12-Lead 3 mm × 3 mm VDFN [JQA] Package Outline and Recommended Land Pattern

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E		0.50 BSC	
Optional Center Pad Width	X2			2.45
Optional Center Pad Length	Y2			1.75
Contact Pad Spacing	C		3.00	
Contact Pad Width (X12)	X1			0.25
Contact Pad Length (X12)	Y1			0.80
Contact Pad to Center Pad (X12)	G1	0.20		
Thermal Via Diameter	V		0.30	
Thermal Via Pitch	EV		1.00	

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
2. For best soldering results, thermal vias, if used, should be filled or tented to avoid solder loss during reflow process

Microchip Technology Drawing C04-3020 Rev. A

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (September 2023)

- Converted Micrel document MIC2298 to Microchip data sheet DS20006794A.
- Minor text changes throughout.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

PART No.	-XX	X	XX	-XX
Device	Over-Voltage Protection (max.)	Junction Temp. Range	Package	Media Type

Device:	MIC2298:		3.5A Minimum, 1 MHz Boost High Brightness White LED Driver
Over-Voltage Protection (max.):	-15	=	15V
Junction Temperature Range:	Y	=	–40°C to +125°C
Package:	ML	=	12-Lead 3 mm × 3 mm VDFN
Media Type:	-TR	=	5000/Reel

Examples:

a) MIC2298-15YML-TR: MIC2298, 15V Over-Voltage Protection (max.), –40°C to +125°C Temp. Range, 12-Lead 3 mm × 3 mm VDFN, 5000/Reel

Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

NOTES:

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