

1.2A, 1.2 MHz/2 MHz Wide Input Range Integrated Switch Boost Regulator

Features

- Wide Input Voltage Range: 4.5V to 20V
- Output Voltage Adjustable to 40V
- 1.2A Switch Current
- MIC2601 Operates at 1.2 MHz
- MIC2602 Operates at 2 MHz
- Stable with Small Size Ceramic Capacitors
- High Efficiency
- Programmable Soft-Start
- <10 μ A Shutdown Current
- Undervoltage Lockout
- Output Overvoltage Protection
- Overtemperature Shutdown
- 8-Lead 2 mm x 2 mm VDFN, No Lead Package
- -40°C to $+125^{\circ}\text{C}$ Junction Temperature Range

Applications

- Multimedia STB/Antenna
- Broadband Communications
- TFT-LCD Bias Supplies
- Bias Supply
- Positive Output Regulators
- SEPIC Converters
- DSL Applications
- Local Boost Regulators

General Description

The MIC2601 and MIC2602 are 1.2 MHz (MIC2601) or 2 MHz (MIC2602), PWM DC/DC boost switching regulators available in a 2 mm x 2 mm VDFN package. High power density is achieved with the MIC2601/2's internal 40V/1.2A switch, allowing it to power large loads in a tiny footprint.

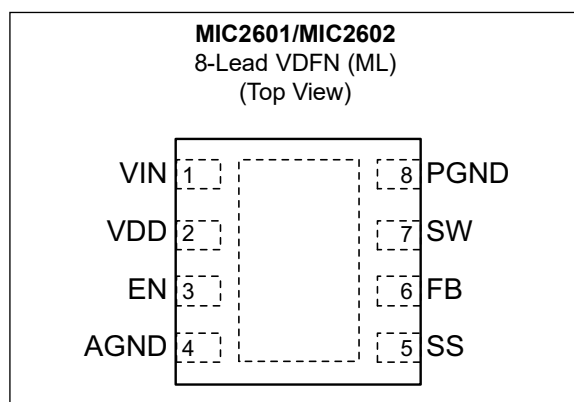
The MIC2601/2 implement constant frequency 1.2 MHz/2 MHz PWM current mode control. The MIC2601/2 offer internal compensation that provides excellent transient response and output regulation performance. The high frequency operation saves board space by allowing small, low-profile external components. The fixed-frequency PWM scheme also reduces spurious switching noise and ripple to the input power source.

Soft-start reduces the inrush current and is programmable via an external capacitor.

The MIC2601 and MIC2602 are available in a 2 mm x 2 mm 8-lead VDFN, no lead package. Both devices have an output overvoltage protection feature.

The MIC2601/2 have an operating junction temperature range of -40°C to $+125^{\circ}\text{C}$.

Package Type



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN})	+22V
Switch Voltage (V_{SW})	–0.3V to +40V
Enable Voltage (V_{EN})	–0.3V to V_{IN}
Feedback Voltage (V_{FB})	+6V
ESD Rating	2 kV

Operating Ratings ‡

Supply Voltage (V_{IN})	+4.5V to +20V
Enable Voltage (V_{EN})	0V to +20V

† **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.

ELECTRICAL CHARACTERISTICS

$T_A = +25^\circ\text{C}$, $V_{IN} = V_{EN} = 12\text{V}$; unless otherwise noted. **Bold** values valid for -40°C to $+125^\circ\text{C}$. (Note 1)

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Input Voltage Range	V_{IN}	4.5	—	20	V	—
Internal Regulated Voltage	V_{DD}	—	6.0	—	V	Note 2
Undervoltage Lockout	V_{UVLO}	1.8	2.1	2.4	V	For V_{DD}
Quiescent Current	I_Q	—	4.2	6	mA	$V_{FB} = 2\text{V}$ (not switching)
Shutdown Current	I_{SD}	—	0.08	2	μA	$V_{EN} = 0\text{V}$, Note 3
Feedback Voltage	V_{FB}	1.235	1.26	1.285	V	$\pm 2\%$
		1.222	—	1.298		$\pm 3\%$ (over temperature)
Feedback Input Current	I_{FB}	—	–550	—	nA	$V_{FB} = 1.25\text{V}$
Line Regulation	—	—	0.04	1	%	$8\text{V} \leq V_{IN} \leq 14\text{V}$, $V_{OUT} = 18\text{V}$
Load Regulation	—	—	0.1	—	%	$5\text{mA} \leq I_{OUT} \leq 400\text{mA}$, $V_{OUT} = 18\text{V}$, Note 4
Internal Soft-Start Resistor	R_{SS}	—	15	—	k Ω	—
Maximum Duty Cycle	DC_{MAX}	85	—	—	%	MIC2601
		80	—	—		MIC2602
Switch Current Limit	I_{SW}	1.2	1.7	—	A	Note 4
Switch Saturation Voltage	V_{SW}	—	500	—	mV	$I_{SW} = 1.2\text{A}$
Switch Leakage Current	I_{SW}	—	0.01	5	μA	$V_{EN} = 0\text{V}$, $V_{SW} = 18\text{V}$
Enable Threshold	V_{EN}	1.5	—	—	V	Turn ON
		—	—	0.3		Turn OFF
Enable Pin Current	I_{EN}	—	18.5	40	μA	$V_{EN} = 12\text{V}$

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ELECTRICAL CHARACTERISTICS (CONTINUED)

$T_A = +25^{\circ}\text{C}$, $V_{IN} = V_{EN} = 12\text{V}$; unless otherwise noted. **Bold** values valid for -40°C to $+125^{\circ}\text{C}$. (Note 1)

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Oscillator Frequency (MIC2601)	f_{SW}	1.02	1.12	1.38	MHz	—
Oscillator Frequency (MIC2602)		1.7	1.92	2.3	MHz	—
Output Overvoltage Protection	V_{OVP}	10	15	20	%	15% over programmed V_{OUT} (rising)
Overtemperature Threshold Shutdown	T_{SD}	—	150	—	$^{\circ}\text{C}$	—
		—	10	—	$^{\circ}\text{C}$	Hysteresis

- Note 1:** Specification for packaged product only.
2: Connect VDD pin to VIN pin when $V_{IN} \leq 7\text{V}$.
3: $I_{\text{SD}} = I_{\text{VIN}}$.
4: Ensured by design.

TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Storage Temperature Range	T_{S}	-65	—	+150	$^{\circ}\text{C}$	—
Lead Temperature	T_{LEAD}	—	—	+260	$^{\circ}\text{C}$	Soldering, 10 sec.
Junction Temperature Range	T_{J}	-40	—	+125	$^{\circ}\text{C}$	—
Package Thermal Resistances						
Thermal Resistance, VDFN 8-Ld	θ_{JA}	—	90	—	$^{\circ}\text{C/W}$	—
	θ_{JC}	—	45	—	$^{\circ}\text{C/W}$	—

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.

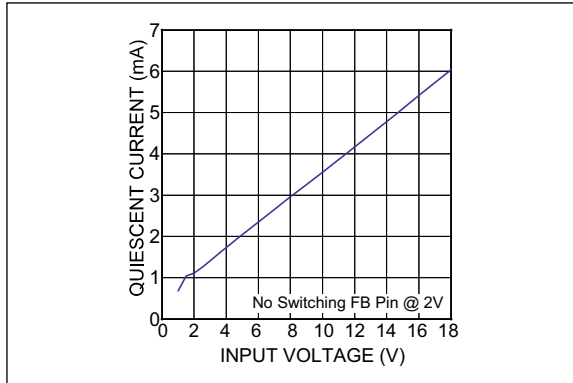


FIGURE 2-1: Quiescent Current vs. Input Voltage.

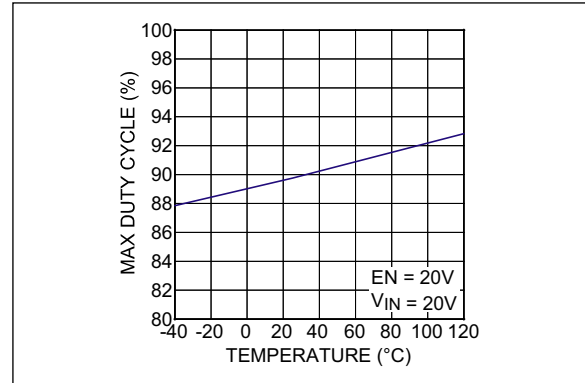


FIGURE 2-4: Maximum Duty Cycle vs. Temperature.

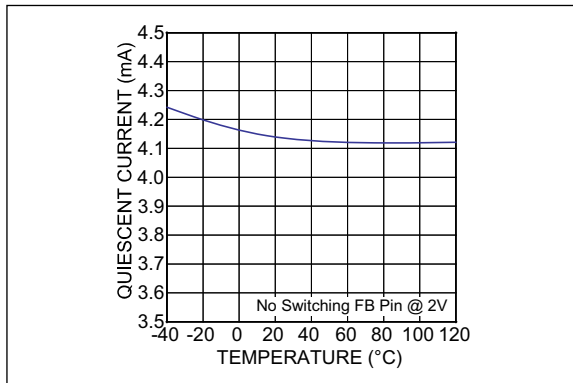


FIGURE 2-2: Quiescent Current vs. Temperature.

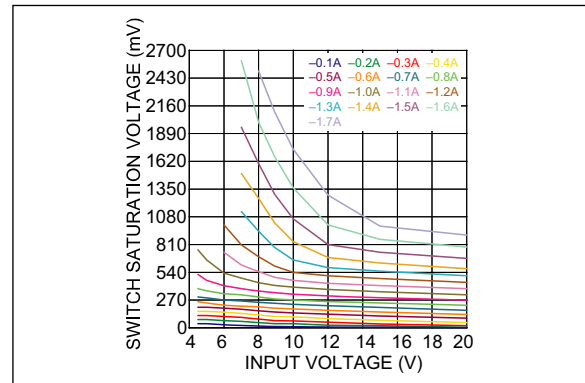


FIGURE 2-5: Switch Saturation Voltage vs. Input Voltage.

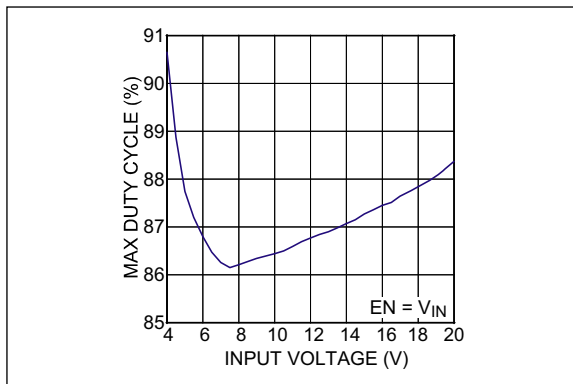


FIGURE 2-3: Maximum Duty Cycle vs. Input Voltage.

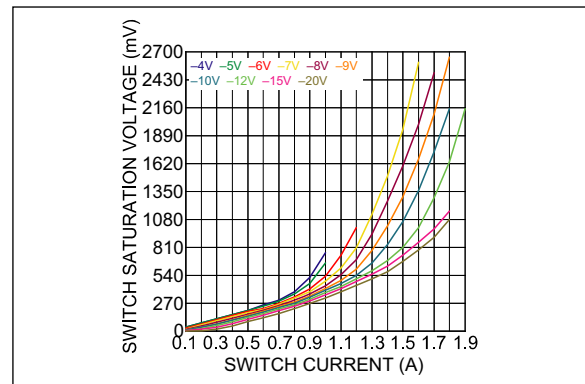


FIGURE 2-6: Switch Saturation Voltage vs. Switch Current.

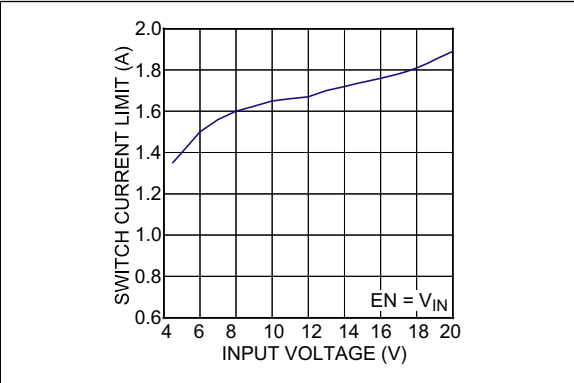


FIGURE 2-7: Switch Current Limit vs. Input Voltage.

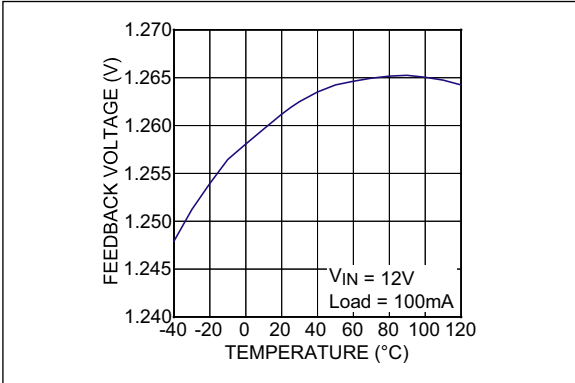


FIGURE 2-10: Feedback Voltage vs. Temperature.

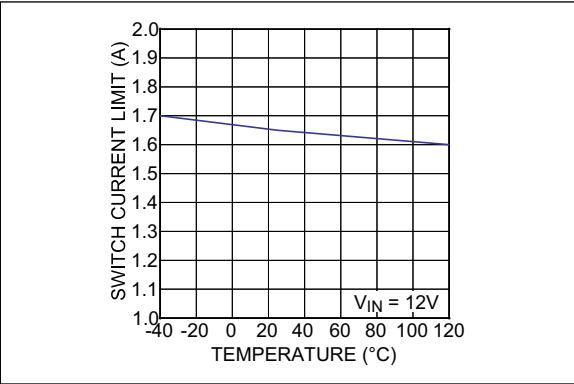


FIGURE 2-8: Switch Current Limit vs. Temperature.

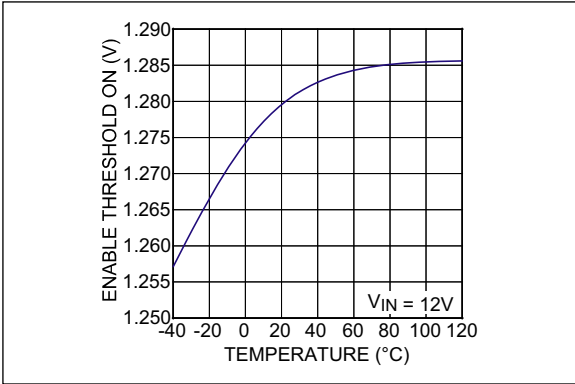


FIGURE 2-11: Enable Threshold ON vs. Temperature.

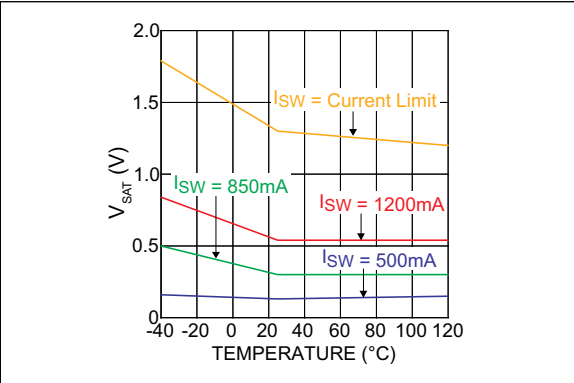


FIGURE 2-9: V_{SAT} vs. Temperature.

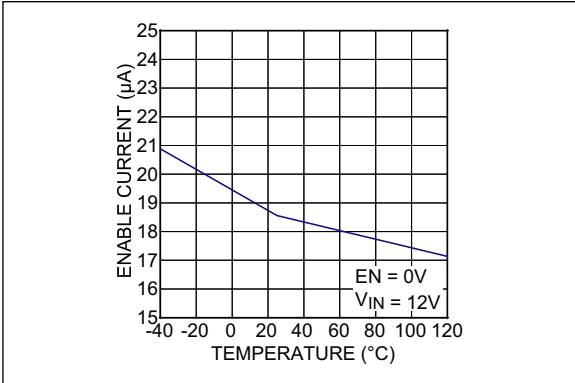


FIGURE 2-12: Enable Current vs. Temperature.

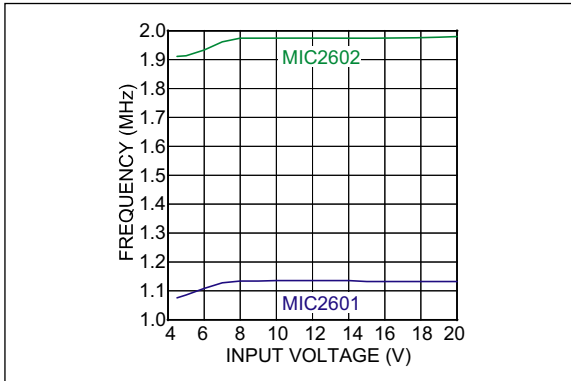


FIGURE 2-13: Frequency vs. Input Voltage.

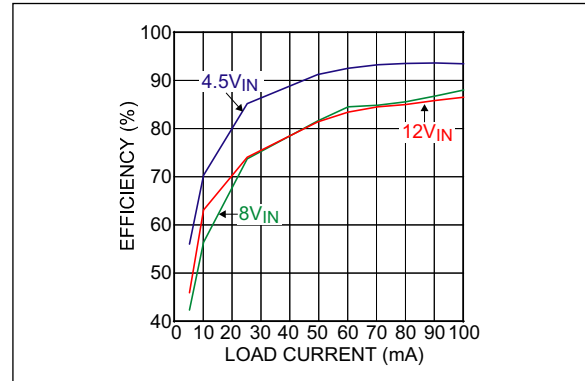


FIGURE 2-16: 18V_{OUT} Efficiency.

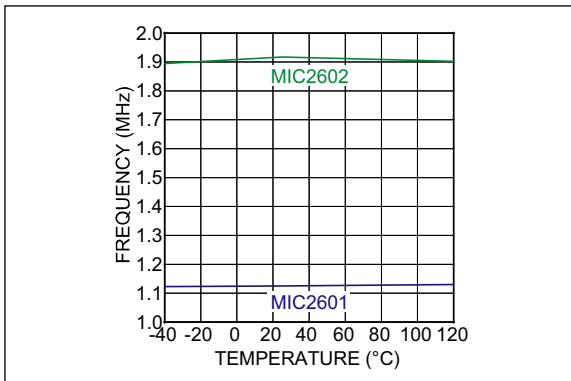


FIGURE 2-14: Frequency vs. Temperature.

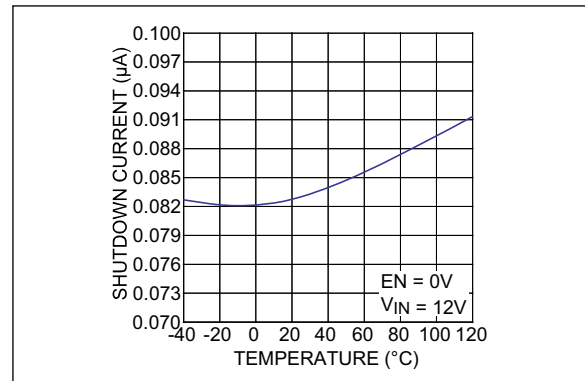


FIGURE 2-17: Shutdown Current vs. Temperature.

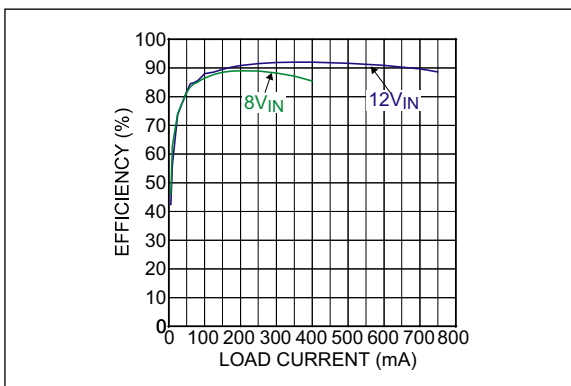


FIGURE 2-15: 18V_{OUT} Efficiency.

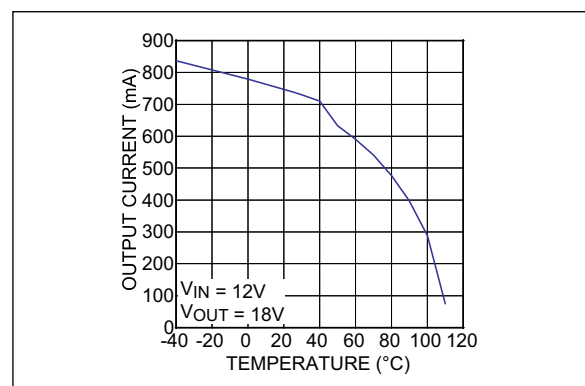


FIGURE 2-18: Thermal Derating.

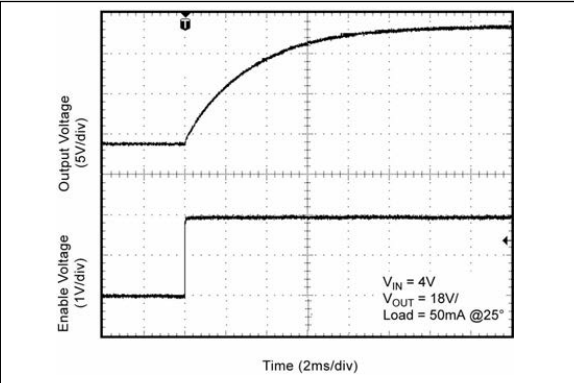


FIGURE 2-19: Enable Turn-On.

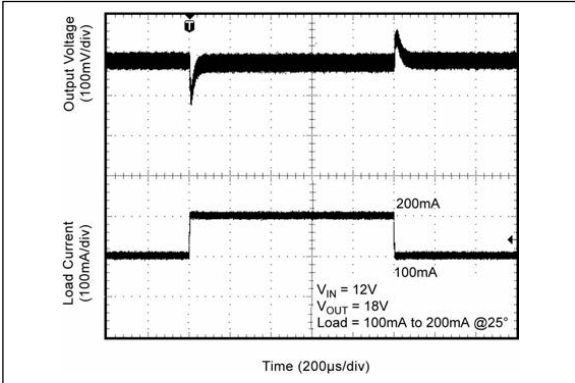


FIGURE 2-21: Load Transient.

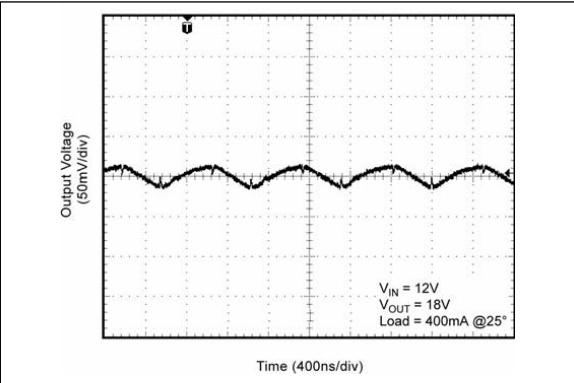


FIGURE 2-20: Ripple Waveform.

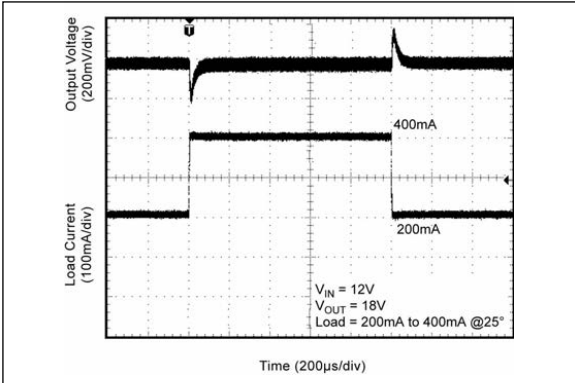


FIGURE 2-22: Load Transient.

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	VIN	Supply (Input): 4.5V to 20V input voltage.
2	VDD	Internal regulator. VDD should be connected to VIN when $V_{IN} \leq 7V$.
3	EN	Enable (Input): Logic high enables regulator. Logic low shuts down regulator.
4	AGND	Analog Ground
5	SS	Soft Start
6	FB	Feedback (Input): 1.25V output voltage sense node. $V_{OUT} = 1.25V \times (1 + R1/R2)$
7	SW	Switch Node (Input): Internal power bipolar collector.
8	PGND	Power ground
EP	GND	Ground (Return): Exposed backside pad. Internally fused to AGND and PGND pins.

4.0 FUNCTIONAL DESCRIPTION

The MIC2601 and MIC2602 are constant frequency, PWM current mode boost regulators. See the [Functional Block Diagram](#). The MIC2601/2 are composed of an oscillator, slope compensation ramp generator, current amplifier, g_m error amplifier, PWM generator, and a 1.2A bipolar output transistor. The oscillator generates a 1.2 MHz (MIC2601) or 2 MHz (MIC2602) clock. The clock's two functions are to trigger the PWM generator that turns on the output transistor and to reset the slope compensation ramp generator. The current amplifier is used to measure the switch current by amplifying the voltage signal from the internal sense resistor. The output of the current amplifier is summed with the output of the slope compensation ramp generator. This summed current-loop signal is fed to one of the inputs of the PWM generator.

The g_m error amplifier measures the feedback voltage through the external feedback resistors and amplifies the error between the detected signal and the 1.25V reference voltage. The output of the g_m error amplifier provides the voltage-loop signal that is fed to the other input of the PWM generator. When the current-loop signal exceeds the voltage-loop signal, the PWM generator turns off the bipolar output transistor. The next clock period initiates the next switching cycle, maintaining the constant frequency current-mode PWM control.

4.1 VIN

VIN provides power to the MOSFETs for the switch mode regulator section. Due to the high switching speeds, a 2.2 μ F capacitor is recommended close to VIN and the power ground (PGND) pin for bypassing. Refer to the layout recommendations for more information.

4.2 VDD

The VDD pin supplies the power to the internal power to the control and reference circuitry. The VDD is powered from VIN. A small 0.1 μ F capacitor is recommended for bypassing.

4.3 EN

The enable pin provides a logic level control of the output. In the off state, supply current of the device is greatly reduced (typically <0.1 μ A). Also, in the off state, the output drive is placed in a "tri-stated" condition, where the bipolar output transistor is in an "off" or non-conducting state. Do not drive the enable pin above the supply voltage.

4.4 SS

The SS pin is the soft-start pin that allows the monotonic buildup of output when the MIC2601/2 come up during turn-on. The SS pin gives the designer the flexibility to have a desired soft-start by placing a capacitor from SS to ground. A 0.1 μ F capacitor is used for in the circuit.

4.5 FB

The feedback pin provides the control path to control the output. For fixed output, the controller output is directly connected to feedback pin.

4.6 SW

The switch pin connects directly to the inductor and provides the switching current necessary to operate in PWM mode. Due to the high speed switching and high voltage associated with this pin, the switch node should be routed away from sensitive nodes.

4.7 PGND

Power ground (PGND) is the ground path for the high current PWM mode. The current loop for the power ground should be as small as possible and separate from the Analog ground (AGND) loop. Refer to the layout considerations for more details.

4.8 AGND

Analog ground (AGND) is the ground path for the biasing and control circuitry. The current loop for the signal ground should be separate from the Power ground (PGND) loop. Refer to the layout considerations for more details.

5.0 APPLICATION INFORMATION

5.1 DC-to-DC PWM Boost Conversions

The MIC2601 and MIC2602 are constant frequency boost converters. They operate by taking a DC input voltage and regulating a higher DC output voltage. Figure 5-1 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, causing the current to be discharged into the output capacitor through an external Schottky diode (D1). Voltage regulation is achieved through pulse-width modulation (PWM).

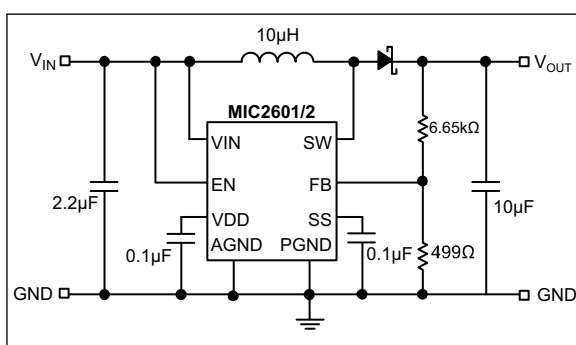


FIGURE 5-1: Typical Application Circuit.

5.2 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 5-1:

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

The duty cycle required for voltage conversion should be less than the maximum duty cycle of 85%. 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 overshoot slightly over 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 reduces peak current, which in turn reduces energy transfer in each cycle.

5.3 Overvoltage Protection

For the MIC2601/2, there is an overvoltage protection function. If the output voltage overshoots the set voltage by 15% when feedback is high during input that is higher than output, turn-on, load transients, line transients, load disconnection, etc., the MIC2601/2 OVP circuit will shut the switch off, saving itself and other sensitive circuitry downstream.

5.4 Component Selection

5.4.1 INDUCTOR

Inductor selection is a balance between efficiency, stability, cost, size, and rated current. For most applications, a 10 µH is the recommended inductor value; it is usually a good balance between these considerations. Large 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. Because the majority of input current (minus the MIC2601 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 5-2:

$$FRHPZ = \frac{(1 - D)^2 \times V_{OUT}}{2 \times \pi \times L \times I_{OUT}}$$

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 a 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).

5.4.2 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

MIC2601/2

for designs with the MIC2601/2. Y5V values may be used, but to offset their tolerance over temperature, more capacitance is required.

5.4.3 DIODE SELECTION

The MIC2601/2 require 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.

5.4.4 INPUT CAPACITOR

A minimum 2.2 μF ceramic capacitor is recommended for designing with the MIC2601/2. 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 MIC2601, with short traces for good noise performance.

5.5 Feedback Resistors

The MIC2601/2 utilize a feedback pin to compare the output to an internal reference. The output voltage is adjusted by selecting the appropriate feedback resistor network values. The R2 resistor value must be less than or equal to 1 k Ω ($R2 \leq 1 \text{ k}\Omega$). The desired output voltage can be calculated as follows:

EQUATION 5-3:

$$V_{OUT} = V_{REF} \times \left(\frac{R1}{R2} + 1 \right)$$

Where:

$V_{REF} = 1.25\text{V}$

6.0 TYPICAL APPLICATION SCHEMATIC

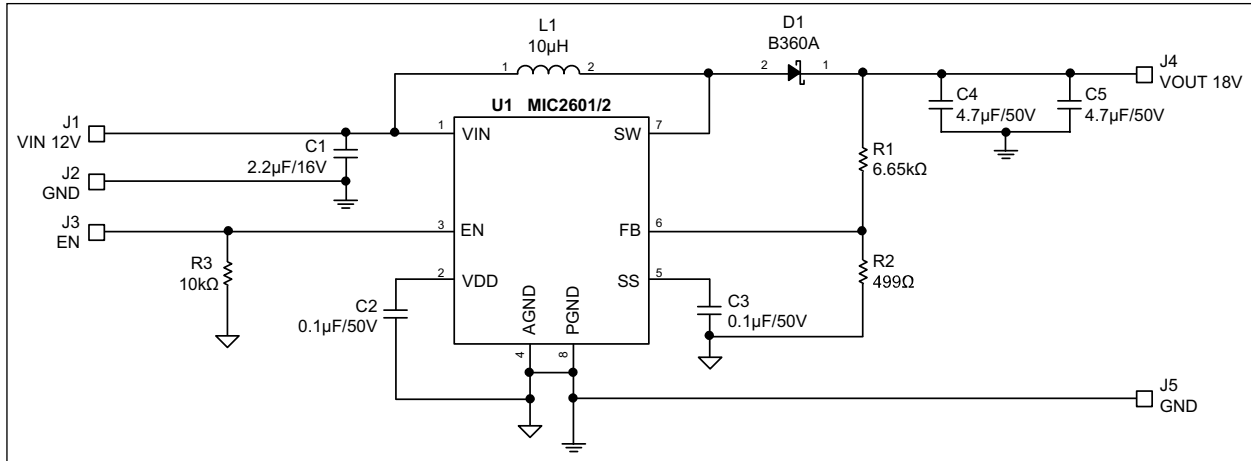


TABLE 6-1: BILL OF MATERIALS

Item	Part Number	Manufacturer	Description	Qty.
C1	GRM21BR71C225KA12L	Murata	Capacitor, 2.2 µF, 16V, X7R, Size 0805	1
	0805YC225MAT	AVX		
C2, C3	VJ0603Y104KXAAT	Vishay Dale	Capacitor, 0.1 µF, 50V, X7R, Size 0603	2
	06035C104MAT	AVX		
	GRM188R71C104KA01D	Murata	Capacitor, 0.1 µF, 16V, X7R, Size 0603	
C4, C5	GRM31CR71H475KA12L	Murata	Capacitor, 4.7 µF, 50V, X7R, Size 1206	2
D1	SS3P6-E3	Vishay Dale	3A, 60V Schottky Diode	1
	B360A	Diodes		
L1	LQH55DN100M03	Murata	10 µH, 1700 mA	1
R1	CRCW06036K65FKEA	Vishay Dale	Resistor, 6.65 kΩ, 1%, 1/10W, Size 0603	1
R2	CRCW06034990FKEA	Vishay Dale	Resistor, 499Ω, 1%, 1/10W, Size 0603	1
R3	CRCW060310K0FKEA	Vishay Dale	Resistor, 10 kΩ, 1%, 1/10W, Size 0603	1
U1	MIC2601YML	Microchip	1.2A, 1.2 MHz Wide Range Integrated Switch Boost Regulator	1
	MIC2602YML		1.2A, 2 MHz Wide Range Integrated Switch Boost Regulator	

7.0 PCB LAYOUT RECOMMENDATIONS

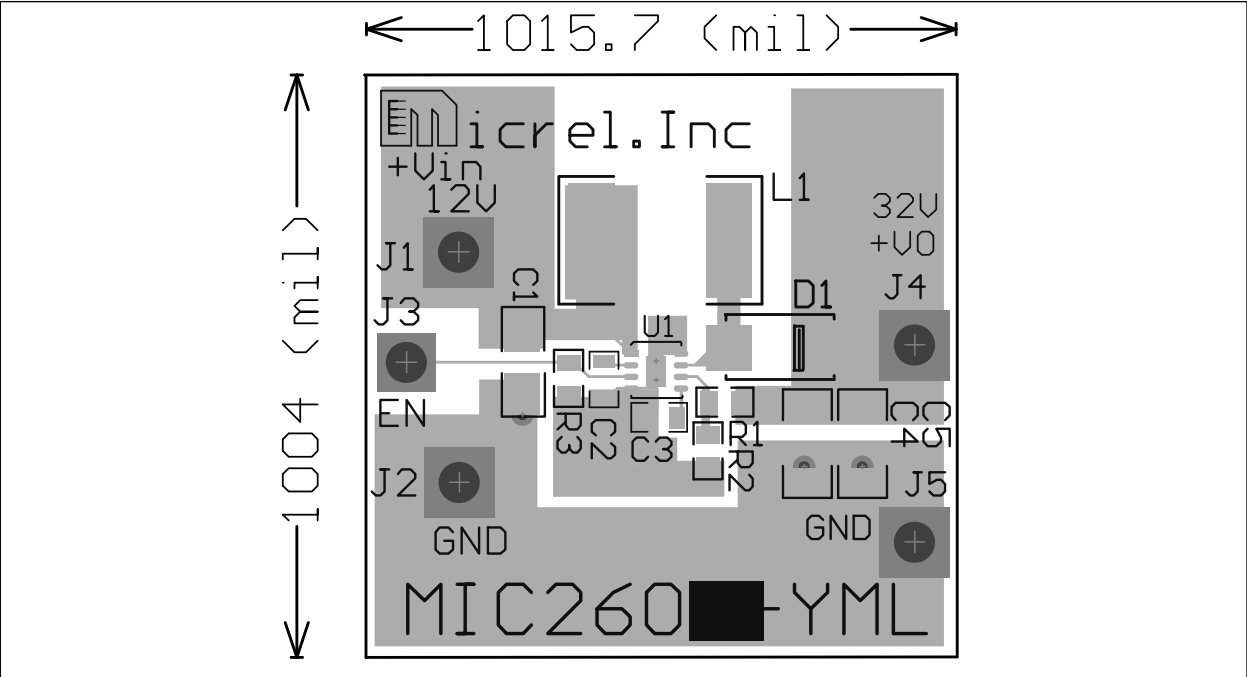


FIGURE 7-1: Top Layer.

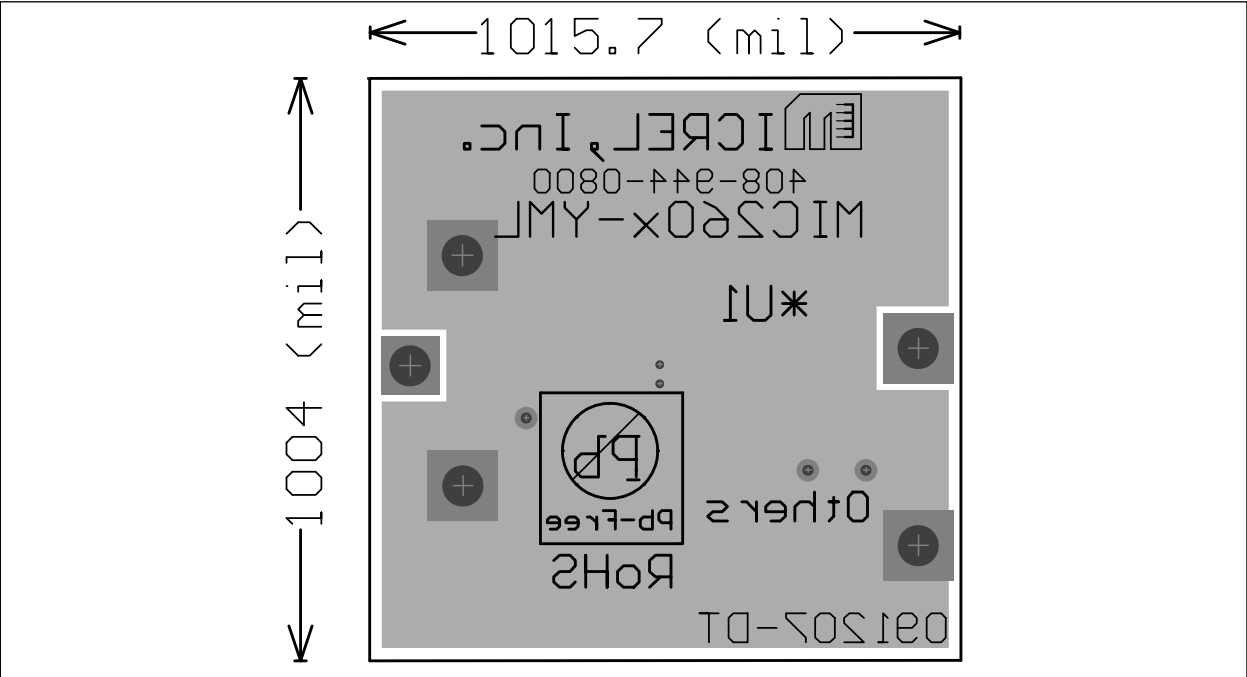
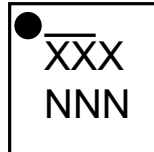


FIGURE 7-2: Bottom Layer.

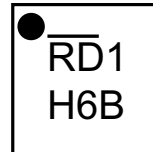
8.0 PACKAGING INFORMATION

8.1 Package Marking Information

8-Lead VDFN*



Example



Legend:	XX...X	Product code or customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) 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:	In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.	
	Underbar (_) and/or Overbar (¯) symbol may not be to scale.	

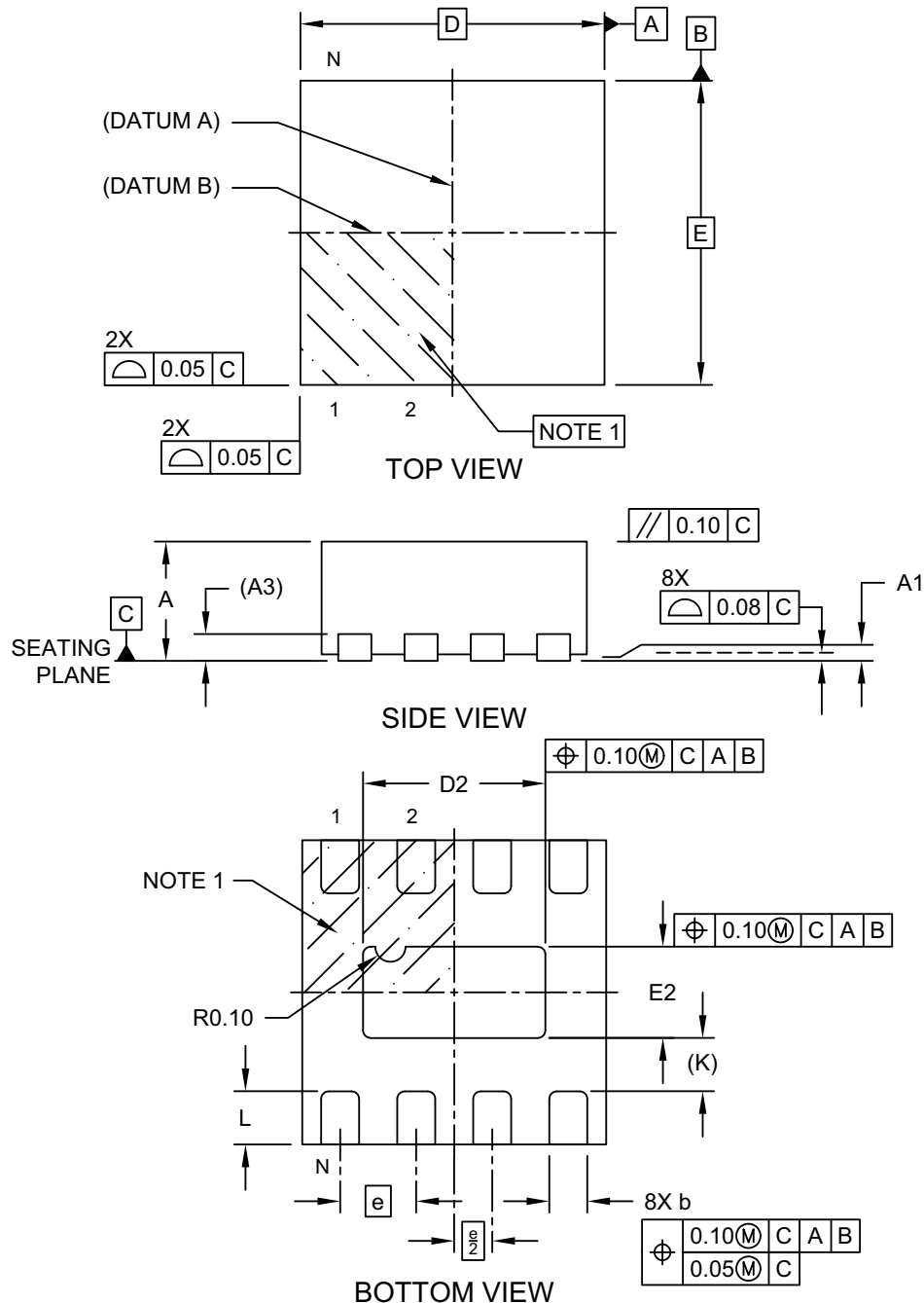
Note: If the full seven-character YYWWNNN code cannot fit on the package, the following truncated codes are used based on the available marking space:

6 Characters = YYWWNNN; 5 Characters = WWNNN; 4 Characters = WNNN; 3 Characters = NNN;
2 Characters = NN; 1 Character = N

MIC2601/2

8-Lead Very Thin Plastic Dual Flat, No Lead Package (H2A) - 2x2x0.9 mm Body [VDFN] With 1.20x0.6 mm Exposed Pad

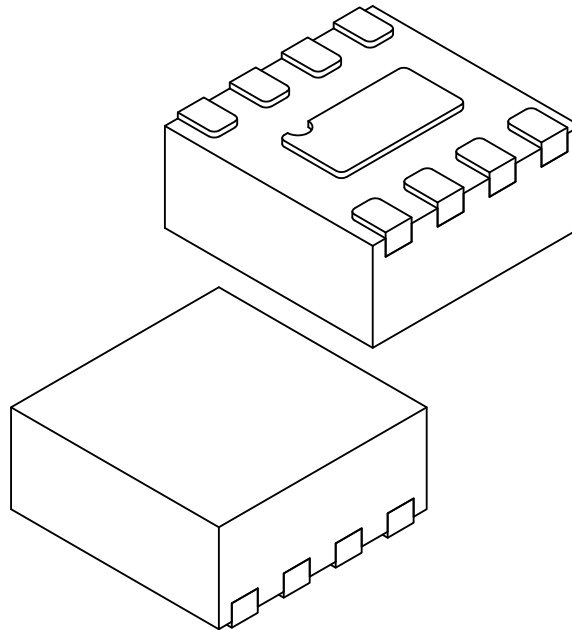
Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Microchip Technology Drawing C04-1247 Rev B Sheet 1 of 2

8-Lead Very Thin Plastic Dual Flat, No Lead Package (H2A) - 2x2x.9 mm Body [VDFN] With 1.20x0.6 mm Exposed Pad

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	8		
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	2.00 BSC		
Exposed Pad Length	D2	1.10	1.20	1.30
Overall Width	E	2.00 BSC		
Exposed Pad Width	E2	0.50	0.60	0.70
Terminal Width	b	0.20	0.25	0.30
Terminal Length	L	0.30	0.35	0.40
Terminal-to-Exposed-Pad	K	0.35 REF		

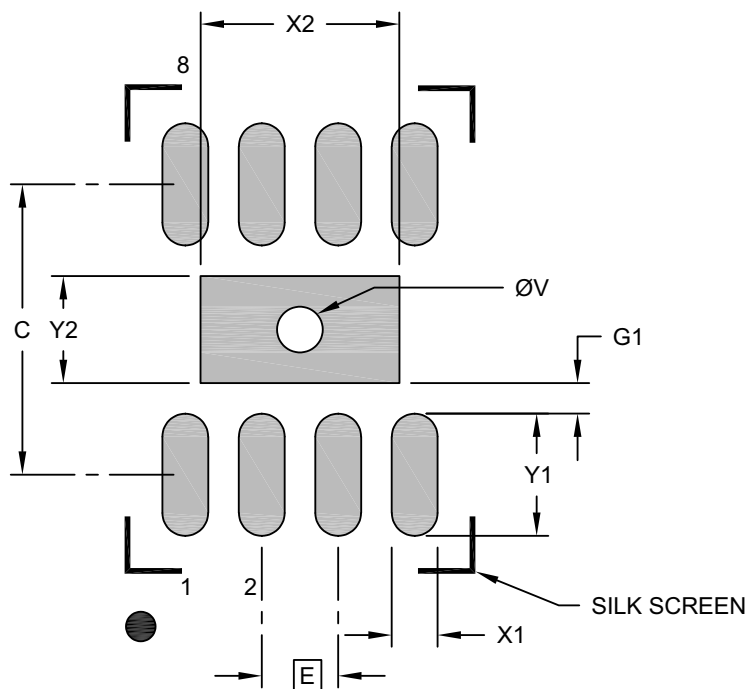
Notes:

- Pin 1 visual index feature may vary, but must be located within the hatched area.
- Package is saw singulated
- 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 C04-1247 Rev B Sheet 2 of 2

8-Lead Very Thin Plastic Dual Flat, No Lead Package (H2A) - 2x2 mm Body [VDFN] Micrel Legacy Package

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			1.30
Optional Center Pad Length	Y2			0.70
Contact Pad Spacing	C		1.90	
Contact Pad Width (X8)	X1			0.30
Contact Pad Length (X8)	Y1			0.80
Contact Pad to Center Pad (X8)	G1	0.20		
Thermal Via Diameter	V	0.27	0.30	0.33

Notes:

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

Microchip Technology Drawing C04-3247 Rev. B

APPENDIX A: REVISION HISTORY

Revision A (March 2025)

- Converted Micrel document MIC2601/2 to Microchip data sheet DS20006902A.
- Minor text changes throughout.

MIC2601/2

NOTES:

PRODUCT IDENTIFICATION SYSTEM

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

<u>Part Number</u>		<u>[X]</u>	<u>X</u>	<u>XX</u>	<u>-XX</u>
Device		Output Overvoltage Protection	Temperature Range	Package	Media Type
Device:	MIC2601:	1.2A, 1.2 MHz Wide Input Range Integrated Switch Boost Regulator			
	MIC2602:	1.2A, 2 MHz Wide Input Range Integrated Switch Boost Regulator			
Output Overvoltage Protection:	<blank>	=	40V		
Temperature Range:	Y	=	-40°C to +125°C		
Package:	ML	=	8-Lead 2 mm x 2 mm VDFN, no lead package		
Media Type:	TR	=	5,000/Reel		

Examples:

a) MIC2601YML-TR: MIC2601, 40V Output Overvoltage Protection, -40°C to +125°C Temp. Range, 8-Lead VDFN, 5,000/Reel

b) MIC2602YML-TR: MIC2602, 40V Output Overvoltage Protection, -40°C to +125°C Temp. Range, 8-Lead VDFN, 5,000/Reel

Note: 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.

MIC2601/2

NOTES:

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