MIC2605/6

0.5A, 1.2 MHz/2 MHz Wide Input Range Boost Regulators, Each with Integrated Switch and Schottky Diode

Features

- Wide Input Voltage Range: 4.5V to 20V
- Output Voltage Adjustable to 40V
- 0.5A Switch Current and Schottky Diode
- MIC2605 Operates at 1.2 MHz
- MIC2606 Operates at 2 MHz
- Programmable Soft-Start
- Stable with Small Size Ceramic Capacitors
- High Efficiency
- Low Input and Output Ripple
- <10 μA shutdown current
- UVLO
- Output Overvoltage and Overtemperature Protection
- 8-lead 2 mm x 2 mm TDFN Package
- –40°C to +125°C Junction Temperature Range

Applications

- TV Tuners
- Broadband Communications
- TFT-LCD Bias Supplies
- Bias Supply
- Positive Output Regulators
- SEPIC Converters
- DSL Applications
- Local Boost Regulators

General Description

The MIC2605 and MIC2606 are PWM DC/DC boost switching regulators each available in a 8-lead 2 mm x 2 mm TDFN package. The only difference between the 2 versions of the device is the switching frequency: The MIC2605 runs at 1.2 MHz, while the MIC2606 runs at 2 MHz. High power density is achieved with the internal 40V switch and 0.5A Schottky diode in both the MIC2605 and MIC2606, allowing them to power large loads in a tiny footprint.

The MIC2605 and MIC2606 implement constant frequency 1.2 MHz and 2 MHz (respectively) PWM current mode control. The MIC2605 and MIC2606 offer internal compensation with 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.

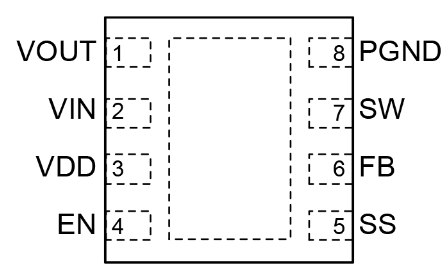
The MIC2605 and MIC2606 are each available in an 8-lead 2 mm × 2 mm TDFN leadless package. This package has an output overvoltage protection feature.

The MIC2605 and MIC2606 both have operating junction temperature ranges of –40°C to +125°C.

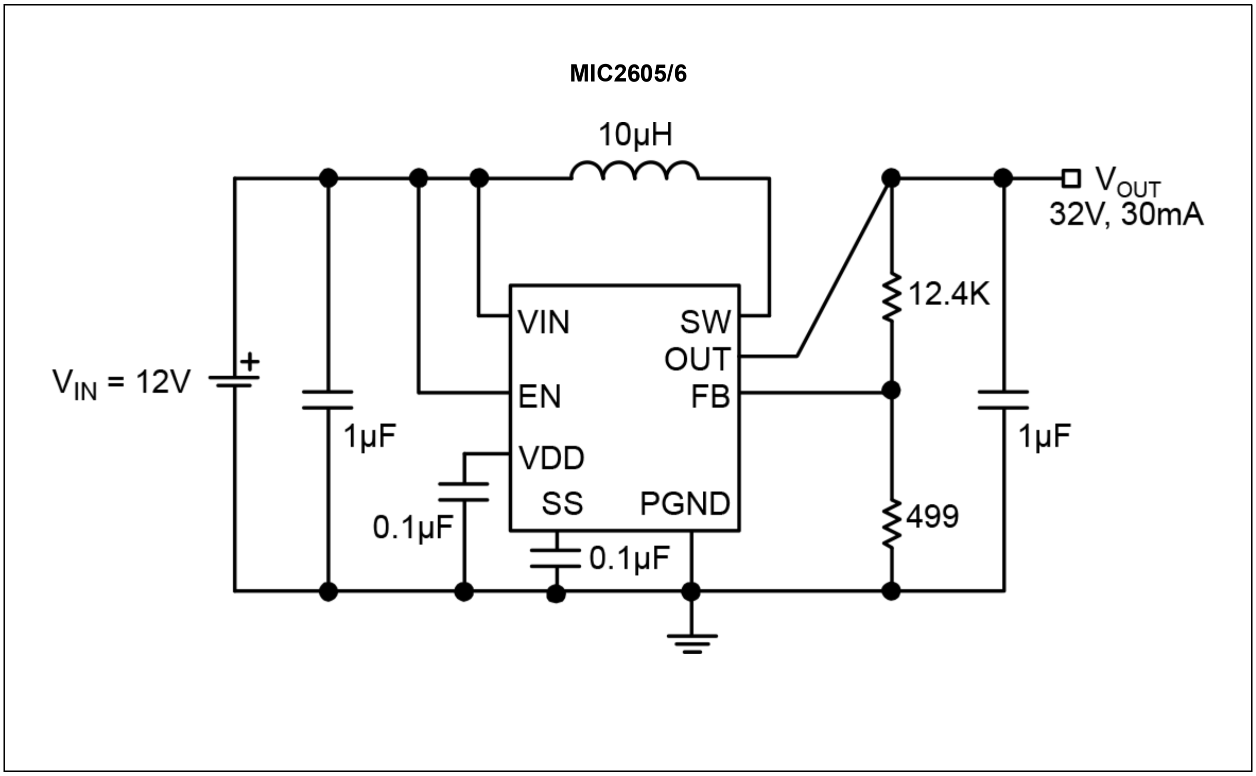
Package Types

MIC2605/6

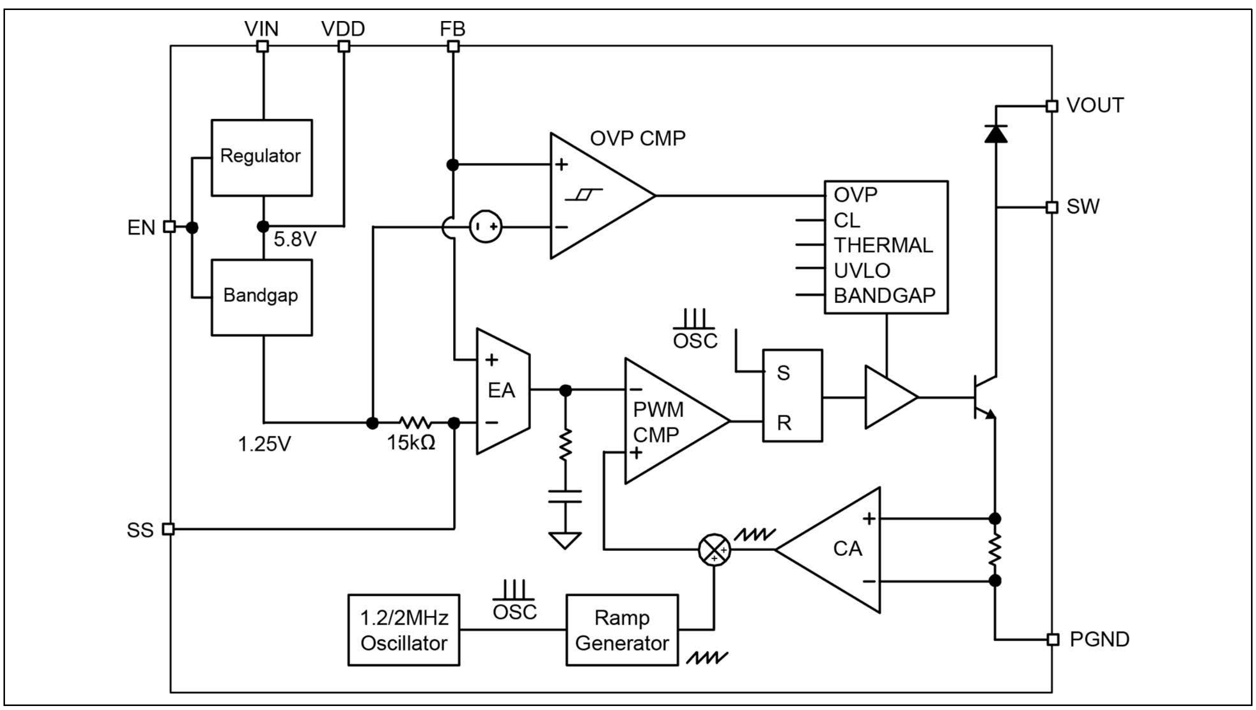
8-Lead TDFN



Typical Application Circuits



Functional Block Diagram



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}
FB Voltage (V_{FB}). .... V_{DD}
ESD Rating (Note 1) (MIC2605) .... 2 kV
ESD Rating (Note 1) (MIC2606) .... 1.5 kV

Operating Ratings ‡

Supply Voltage (V_{IN}) .... 4.5V 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.

Note 1: IC devices are inherently ESD sensitive. Handling precautions required. Human body model rating: 1.5 kΩ in series with 100 pF.

ELECTRICAL CHARACTERISTICS (Note 1)

T_A = 25°C, V_{IN} = V_{EN} = 12V, unless otherwise noted. **Bold** values indicate –40°C ≤ T_J ≤ +125°C.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Input Voltage Range	V_{IN}	4.5	—	20	V	—
Internal Regulated Voltage	V_{DD}	—	5.8	—	V	Note 2
Under-Voltage Lockout	V_{ULVO}	1.8	2.1	2.4	V	For V_{DD}
Quiescent Current	I_Q	—	4.2	6	mA	V_{FB} = 2V (not switching)
Shutdown Current	I_{SD}	—	0.1	10	µA	V_{EN} = 0V, Note 3
Feedback Voltage	V_{FB}	1.225	1.25	1.275	V	(±2%)
		1.212	—	**1.288**	V	(±3%) (overtemperature)
Feedback Input Current	I_{FB}	—	–550	—	nA	V_{FB} = 1.25V
Line Regulation	ΔV_{LNR}	—	0.04	1	%	8V ≤ V_{IN} ≤ 14V, V_{OUT} = 18V
Load Regulation	ΔV_{LDR}	—	—	1.5	%	5 mA ≤ I_{OUT} ≤ 40 mA, V_{OUT} = 18V, Note 4
Maximum Duty Cycle	D_{MAX}	85	—	—	%	MIC2605
		80	—	—	%	MIC2606
Switch Current Limit	I_{SW}	0.5	0.8	—	A	Note 4
Switch Saturation Voltage	V_{SW}	—	600	—	mV	I_{SW} = 0.5A
Switch Leakage Current	I_{SW}	—	0.01	5	µA	V_{EN} = 0V, V_{SW} = 18V
Enable Threshold	V_{EN}	1.5	—	—	V	Turn ON
		—	—	0.3	V	Turn OFF
Enable Pin Current	I_{EN}	—	20	40	µA	V_{EN} = 12V
Oscillator Frequency (MIC2605)	f_{SW}	**1.02**	1.2	**1.38**	MHz	—
Oscillator Frequency (MIC2606)	f_{SW}	**1.7**	2	**2.3**	MHz	—
Schottky Forward Drop	V_D	—	450	—	mV	I_D = 1 mA
		—	850	—	mV	I_D = 150 mA

ELECTRICAL CHARACTERISTICS (Note 1)

T_A = 25°C, V_{IN} = V_{EN} = 12V, unless otherwise noted. **Bold** values indicate –40°C ≤ T_J ≤ +125°C.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Schottky Leakage Current	I_{RD}	—	0.1	4	µA	V_R = 30V
Output Overvoltage Protection	V_{OVP}	10	15	20	%	15% over programmed V_{OUT}
Overtemperature Threshold Shutdown	T_J	—	150	—	°C	—
		—	10	—	°C	Hysteresis

Note 1: Specification for packaged product only.

2: Connect V_{DD} pin to V_{IN} pin when V_{IN} ≤ 7V.

3: I_{SD} = I_{VIN}.

4: Ensured by design.

TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Operating Junction Temperature Range	T_J	–40	—	+125	°C	—
Lead Temperature	—	—	—	+260	°C	Soldering 10 seconds
Ambient Storage Temperature	T_S	–65	—	+150	°C	—
Package Thermal Resistance						
Junction Thermal Resistance, 8-pin 2mm x 2mm TDFN leadless package	θ_{JA}	—	90	—	°C/W	—
	θ_{JC}	—	45	—	°C/W	—

Note 1: The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e., T_A, T_J, θ_{JA}). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum rating. Sustained junction temperatures above that maximum can impact device reliability.

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.

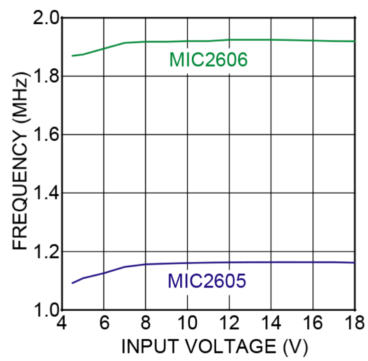


FIGURE 2-1: *Frequency vs. Input Voltage.*

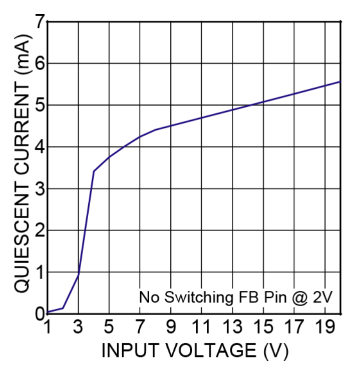


FIGURE 2-2: *Quiescent Current vs. Input Voltage.*

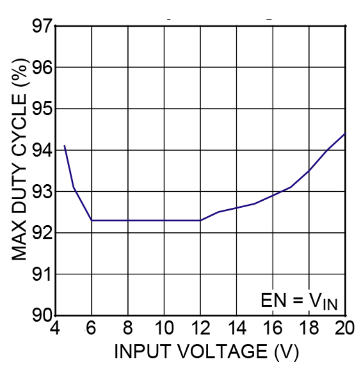


FIGURE 2-3: *Max Duty Cycle vs. Input Voltage.*

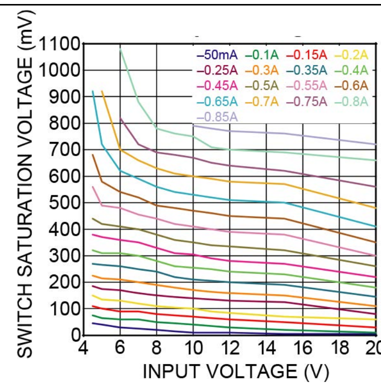


FIGURE 2-4: *Switch Saturation Voltage vs. Input Voltage.*

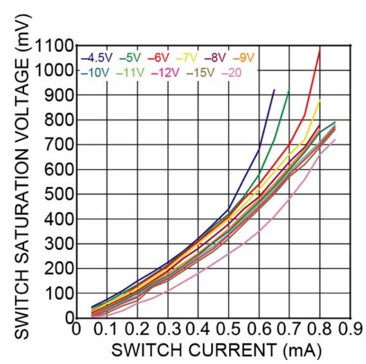


FIGURE 2-5: *Switch Saturation Voltage vs. Switch Current.*

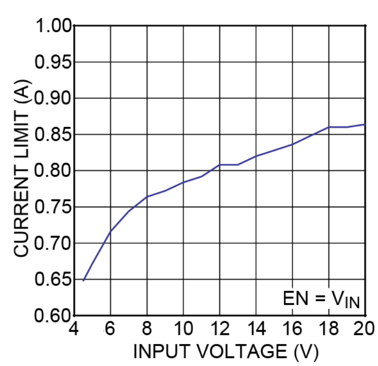


FIGURE 2-6: *Switch Current Limit vs. Input Voltage.*

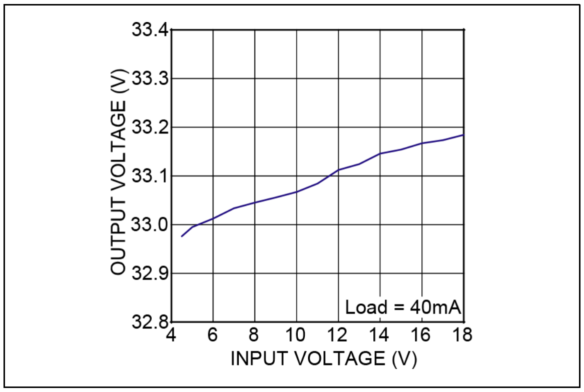


FIGURE 2-7: *Line Regulation.*

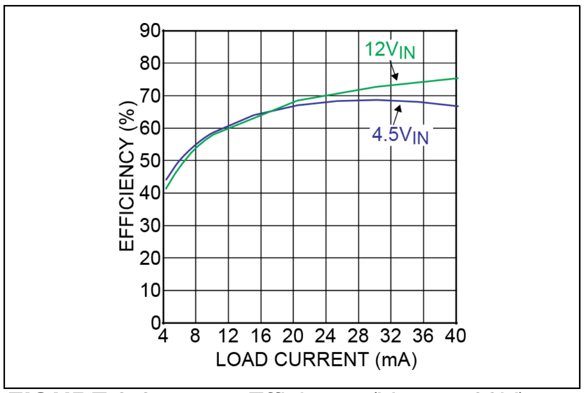


FIGURE 2-8: *Efficiency (V_{OUT} = 32V).*

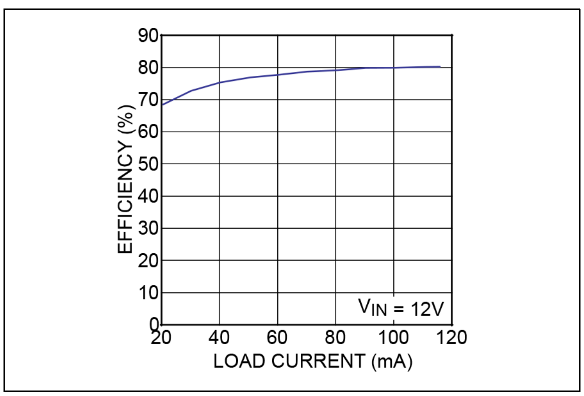


FIGURE 2-9: *Efficiency (V_{OUT} = 32V).*

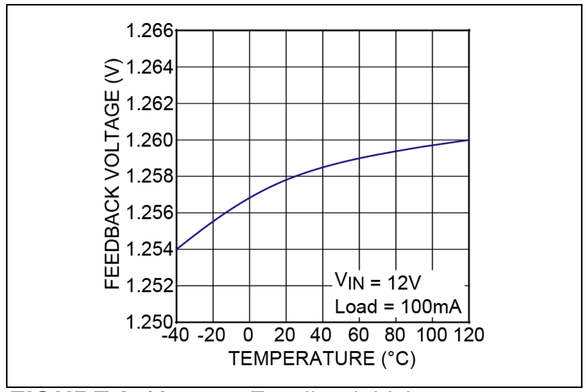


FIGURE 2-10: *Feedback Voltage vs. Temperature.*

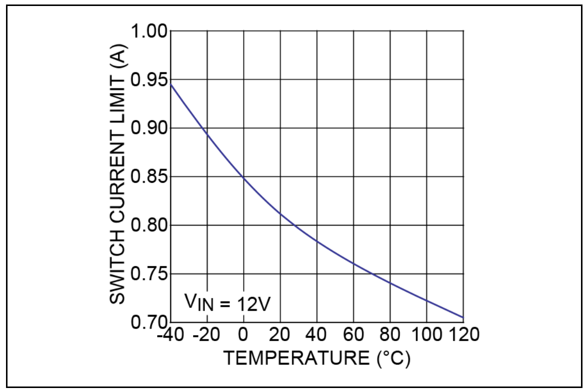


FIGURE 2-11: *Switch Current Limit vs. Temperature.*

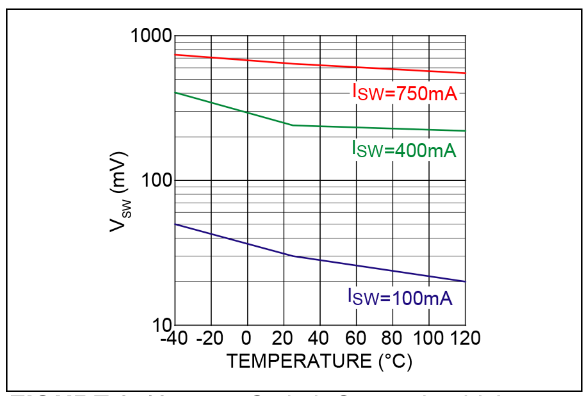


FIGURE 2-12: *Switch Saturation Voltage (V_{SW}) vs. Temperature.*

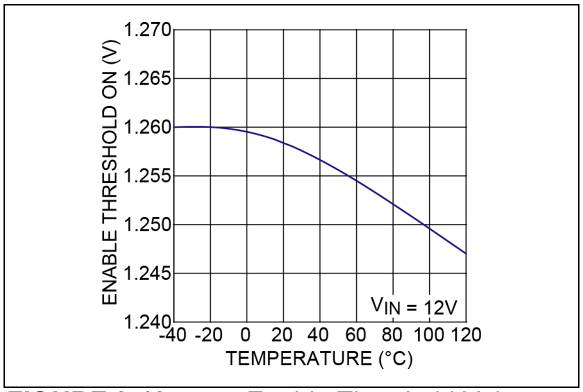


FIGURE 2-13: *Enable Threshold Voltage (V_{EN}) vs. Temperature.*

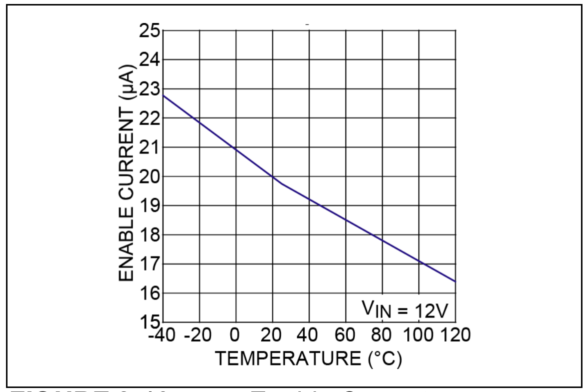


FIGURE 2-16: *Enable Current vs. Temperature.*

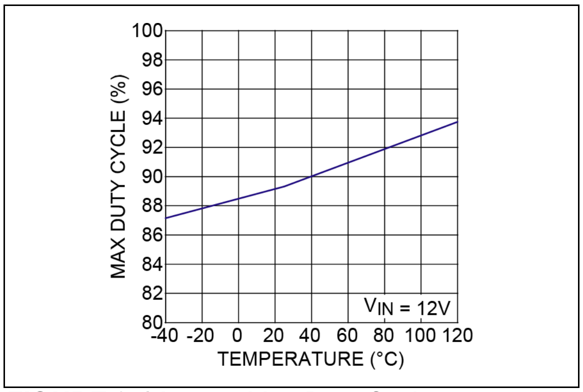


FIGURE 2-14: *Max Duty Cycle vs. Temperature.*

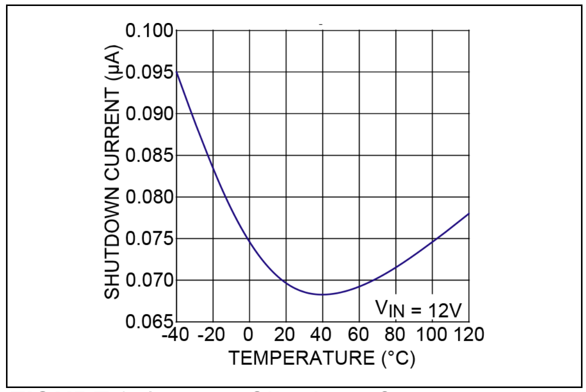


FIGURE 2-17: *Shutdown Current vs. Temperature.*

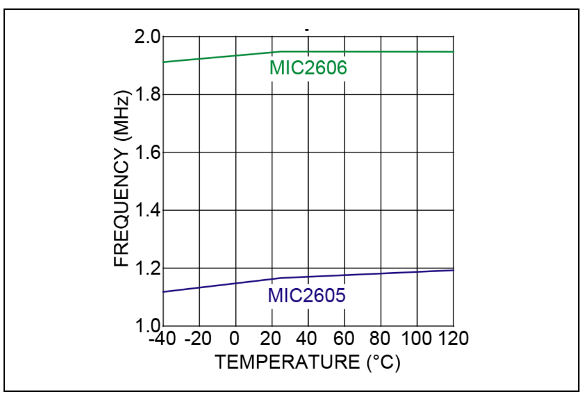


FIGURE 2-15: *Frequency vs. Temperature.*

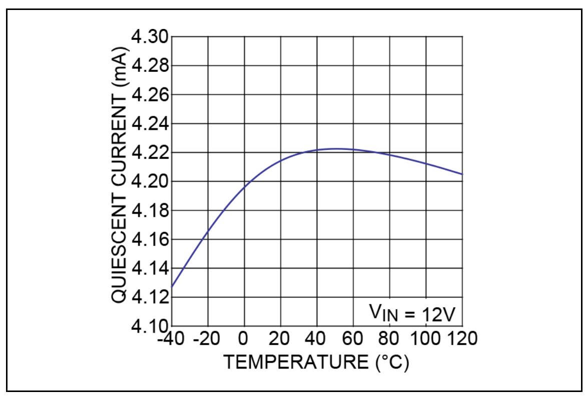


FIGURE 2-18: *Quiescent Current vs. Temperature.*

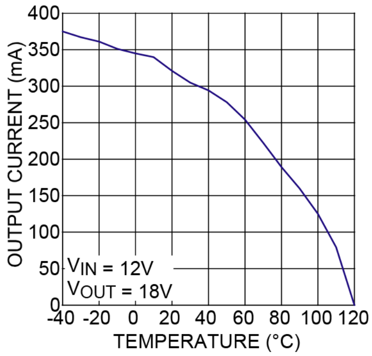


FIGURE 2-19: *Thermal Derating.*

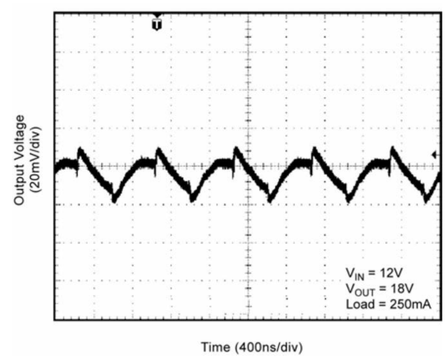


FIGURE 2-22: *Ripple Waveform.*

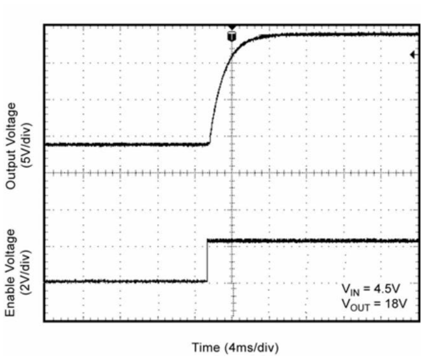


FIGURE 2-20: *Enable Turn-On.*

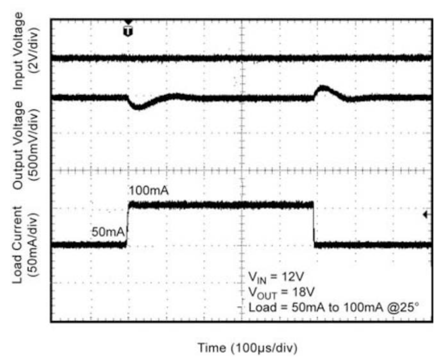


FIGURE 2-23: *Load Transient.*

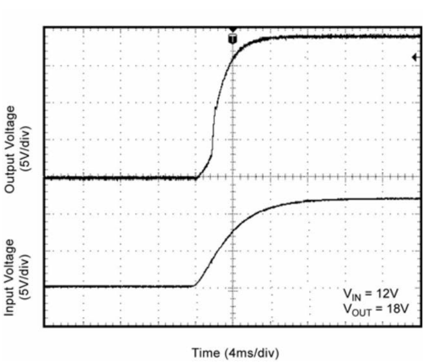


FIGURE 2-21: *Input Turn-On.*

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	VOUT	Output Pin: Connect to the output capacitor.
2	VIN	Supply (Input): 4.5V to 20V input voltage.
3	VDD	Internal Regulated Supply. The VDD should be connected to the VIN when V_{IN} ≤ 7V.
4	EN	Enable (Input): Logic high enables regulator. Logic low shuts down regulator.
5	SS	Soft Start.
6	FB	Feedback Voltage Pin (Input).
7	SW	Switch Node (Input): Connected to the collector of the internal power BIPOLAR.
8	PGND	Power Ground.
EP	EPAD	Exposed Backside Pad for Thermal Cooling.

3.1 Functional Description

The MIC2605 and MIC2606 are constant frequency, PWM current mode boost regulators. The block diagram is shown in Functional Block Diagram. The MIC2605 and MIC2606 are each composed of an oscillator, slope compensation ramp generator, current amplifier, g_m error amplifier, PWM generator, and a 0.5A bipolar output transistor. The oscillator generates a 1.2 MHz clock for the MIC2605 and a 2 MHz clock for the MIC2606.

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.

3.2 Pin Description

3.2.1 VIN

The VIN provides power to the MOSFETs for the switch mode regulator section. Due to the high switching speeds, a 1 µF capacitor is recommended close to VIN and the power ground (PGND) pin for bypassing.

3.2.2 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 µF capacitor is recommended for bypassing.

3.2.3 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 µA). Also, in the off state, the output drive is placed in a "tri-stated" condition, where bipolar output transistor is in an “off” or non-conducting state. Do not drive the enable pin above the supply voltage.

3.2.4 SS

The SS pin is the soft start pin which allows the monotonic buildup of output when the MIC2605 or MIC2606 comes up during turn on. The SS pin gives the designer the flexibility to have a desired soft start by placing a capacitor SS to ground. A 0.1 µF capacitor is used to set the soft start ramp behavior

3.2.5 FB

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

3.2.6 SW

The switch (SW) 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.

3.2.7 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.

3.2.8 VOUT

The VOUT pin is the cathode of pin of internal Schottky diode. This pin is connected to output cap. At least 1 µF cap is recommended very close to the VOUT pin and the PGND.

4.0 APPLICATION INFORMATION

4.1 DC-to-DC PWM Boost Conversion

The MIC2605 and MIC2606 are constant frequency boost converters. They operate by taking a DC input voltage and regulating a higher 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, causing the current to be discharged into the output capacitor through an internal Schottky diode. Voltage regulation is achieved through pulse-width modulation (PWM).

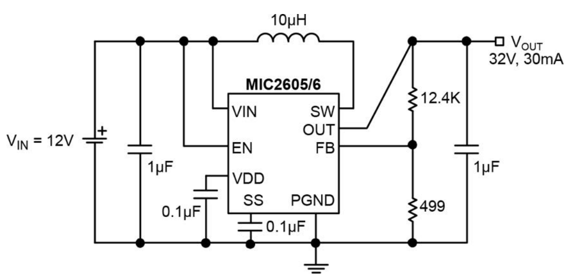


FIGURE 4-1: Typical Application Circuit.

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 4-1:

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

The duty cycle required for voltage conversion should be less than the maximum duty cycle of 85% for the MIC2605 and 80% for the MIC2606. 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.

4.3 Overvoltage Protection

There is an overvoltage protection function for both the MIC2605 and the MIC2606. If the output voltage overshoots the set voltage by 15% when feedback is high during input higher than output, turn on, load transients, line transients, load disconnection, etc. The MIC2605 or MIC2606 OVP circuit will shut the switch off, protecting itself and other sensitive circuitry downstream.

4.4 Component Selection

4.4.1 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 an 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 MIC2605/6 operating currents) 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 4-2:

$$FRHPZ = \frac{(1-D)^2 \times V_O}{2 \times \pi \times L \times I_O}$$

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).

4.4.2 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 for designs with the MIC2605 and the MIC2606. Y5V values may be used, but to offset their tolerance overtemperature, more capacitance is required.

4.4.3 INPUT CAPACITOR

A minimum 1 µF ceramic capacitor is recommended for designing with the MIC2605 and the MIC2606. Increasing input capacitance will improve performance and greater noise immunity on the source. The input capacitor should be as close as possible to input voltage pin (VIN) of the device for good noise performance.

4.4.4 FEEDBACK RESISTORS

The MIC2605 and the MIC2606 each 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 kΩ (R2 ≤ 1 kΩ). The desired output voltage can be calculated as follows:

EQUATION 4-3:

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

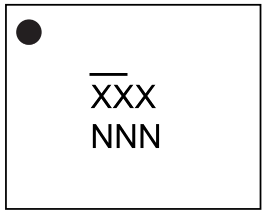
Where:

V_{REF} = 1.25V

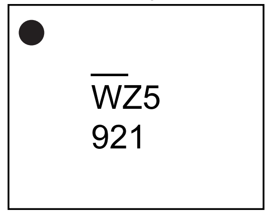
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

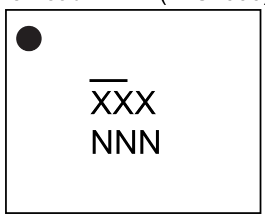
8-Lead TDFN (MIC2605)*



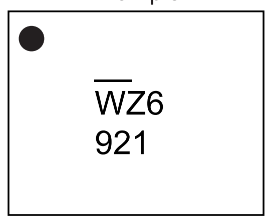
Example



8-Lead TDFN (MIC2606)*



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).

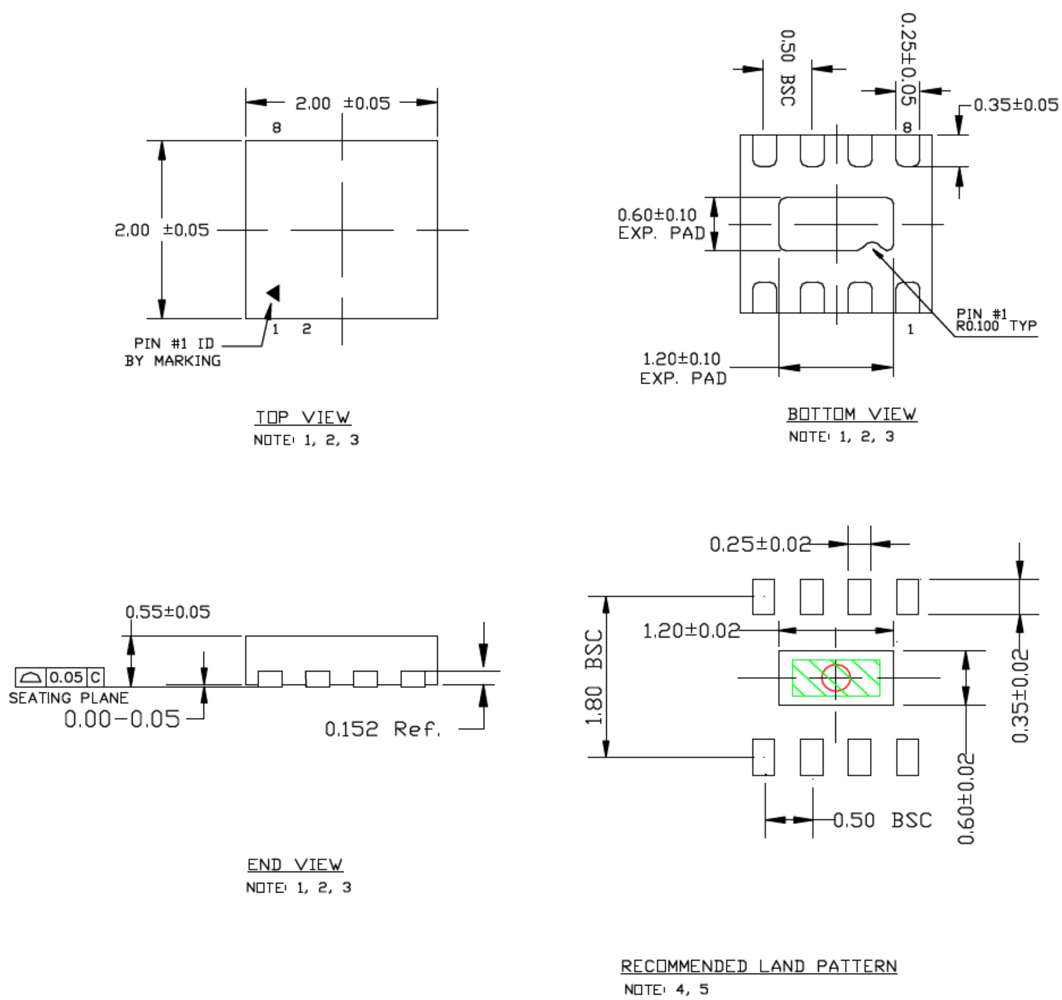
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

Underbar (_) and/or Overbar (‾) symbol may not be to scale.

8-Lead TDFN Package Outline and Recommended Land Pattern

TITLE
8 LEAD TDFN 2x2mm PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	TDFN22-8LD-PL-1	**UNIT**	MM



NOTE:
1. MAX PACKAGE WARPAGE IS 0.05 MM
2. MAX ALLOWABLE BURR IS 0.076MM IN ALL DIRECTIONS
3. PIN #1 IS ON TOP WILL BE LASER MARKED
4. RED CIRCLE IN LAND PATTERN REPRESENTS THERMAL VIA. SIZE SHOULD BE 0.30-0.3 MM IN DIAMETER AND SHOULD BE CONNECTED TO GND FOR MAX THERMAL PERFORMANCE
5. GREEN RECTANGLES (SHADED AREA) REPRESENTS SOLDER STENCIL OPENING ON EXPOSED PAD AREA. SIZE SHOULD BE 0.40x0.90 MM.

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

APPENDIX A: REVISION HISTORY

Revision A (November 2021)

- Converted Micrel document MIC2605/6 to Microchip data sheet DS20006620A.
- 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.	X	XX	-XX
Device	Junction Temp. Range	Package	Media Type

Device:	MIC2605:	0.5A, 1.2 MHz Wide Input Range Boost Regulator
	MIC2606:	0.5A, 2 MHz Wide Input Range Boost Regulator
Junction Temperature Range:	Y =	–40°C to +125°C
Package:	ML =	8-Lead TDFN
Media Type:	-TR =	5000/Reel

Examples:

MIC2605YML-TR	MIC2605, –40°C to +125°C Temp. Range, 8-Lead TDFN, 5000/Reel
MIC2606YML-TR	MIC2606, –40°C to +125°C Temp. Range, 8-Lead TDFN, 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:

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods being used in attempts to breach the code protection features of the Microchip devices. We believe that these methods require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Attempts to breach these code protection features, most likely, cannot be accomplished without violating Microchip's intellectual property rights.
- Microchip is willing to work with any customer who is concerned about the integrity of its code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is "unbreakable." Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

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