

Low Input Voltage, 160 V_{PP} Output Voltage, EL Driver

Features

- 1.8V to 5.5V DC Input Voltage
- 160 V_{PP} Regulated AC Output Waveform
- Independently Adjustable EL Lamp Frequency
- Independently Adjustable Boost Converter Frequency
- 0.1 μ A Shutdown Current

Applications

- LCD Panel Backlight
- Cellular Phones
- PDAs
- Pagers
- Calculators
- Remote Controls
- Portable Phones

General Description

The MIC4826 is a high output voltage, DC to AC converter, designed for driving Electroluminescent (EL) lamps. The device operates from an input voltage range of 1.8V to 5.5V, making it suitable for 1-cell Li Ion and 2- or 3-cell alkaline, NiCad, and NiMH battery applications. The MIC4826 converts a low voltage DC input to a 160 V_{PP} AC output signal that drives the EL lamp.

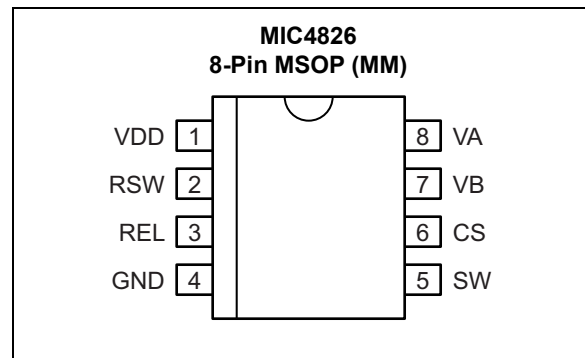
The MIC4826 has two stages: a boost stage, and an H-bridge lamp driver stage. The boost stage steps the input voltage up to +80V. The H-bridge stage then alternately switches the +80V output to each terminal of the EL lamp, thus creating a 160 V_{PP} AC signal to drive the EL lamp and generate light.

The MIC4826 features separate oscillators for the boost and H-bridge stages. External resistors independently set the operating frequency of each stage. This flexibility allows the EL lamp circuit to be optimized for maximum efficiency and brightness.

The MIC4826 uses a single inductor and a minimum number of external components, making it ideal for portable, space-sensitive applications.

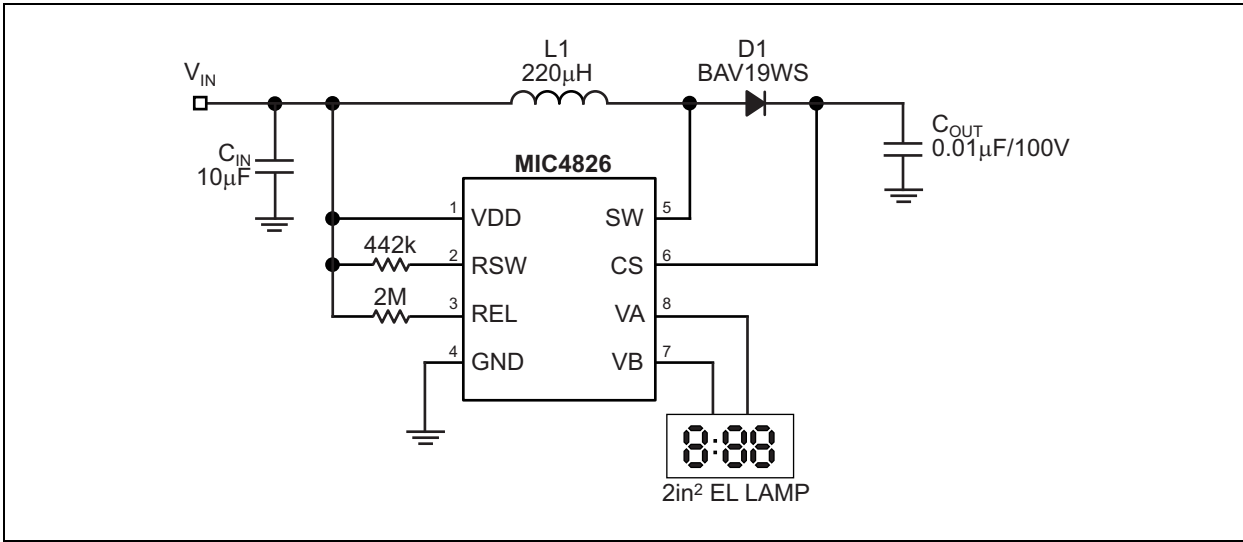
The MIC4826 is available in an 8-lead MSOP package with an ambient temperature range of -40°C to +85°C.

Package Type

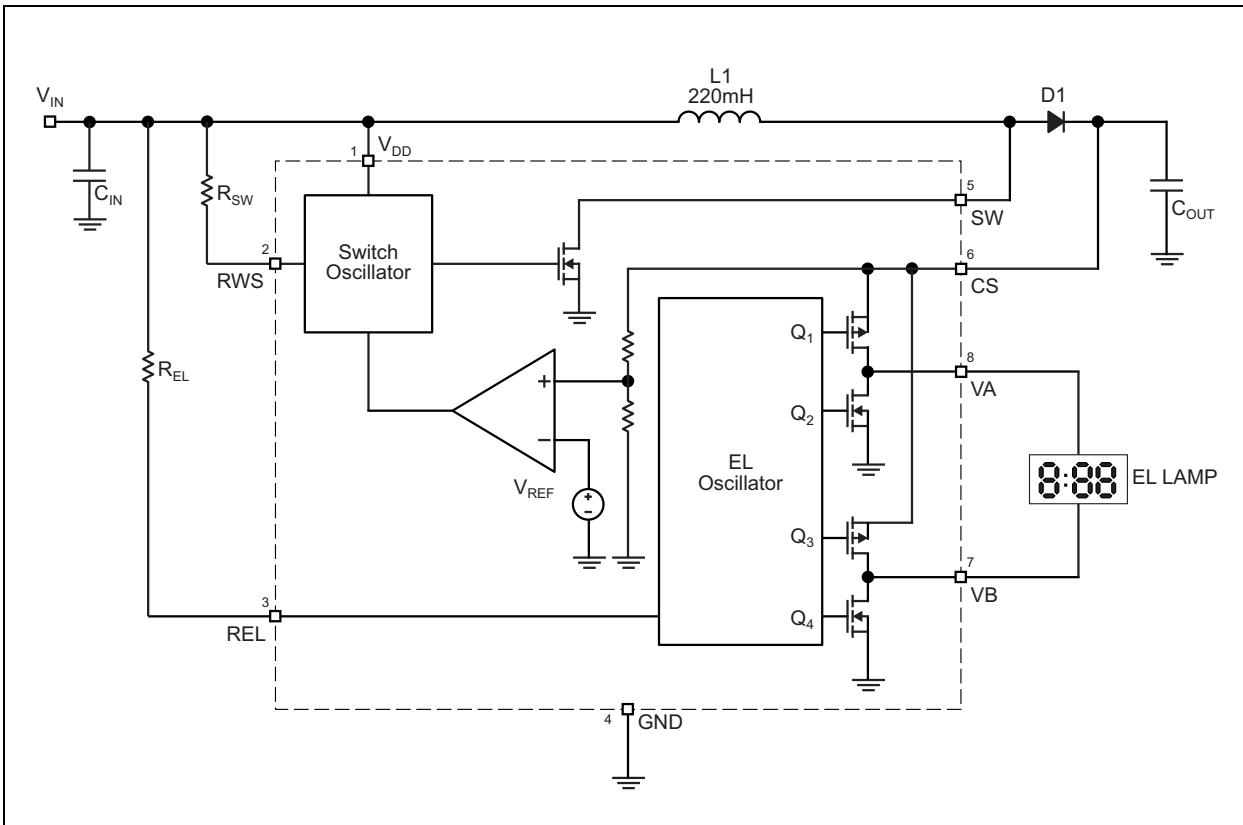


MIC4826

Typical Application Circuit



Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{DD})	–0.5V to +6V
Output Voltage (V_{CS})	–0.5V to +100V
Frequency Control Voltage (V_{RSW} , V_{REL})	–0.5V to ($V_{DD} + 0.3V$)
Power Dissipation @ $T_A = 85^\circ C$	200 mW
Storage Temperature (T_S)	–65°C to +150°C
ESD Rating	(Note 1)

Operating Ratings ‡

Supply Voltage (V_{DD})	+1.8V to +5.5V
Lamp Drive Frequency (f_{EL})	60 Hz to 1000 Hz
Switching Transistor Frequency (f_{SW})	8 kHz to 200 kHz
Ambient Temperature	–40°C to +85°C
Package Thermal Resistance ($R\theta_{(JA)}$, 8-Pin MSOP)	206°C/W

† **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. Specifications are for packaged product only.

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

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

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: $V_{IN} = V_{DD} = 3.0V$, $R_{SW} = 560\text{ k}\Omega$, $R_{EL} = 1.0\text{ M}\Omega$, $T_A = 25^\circ C$ unless otherwise noted. **Bold** values indicate $-40^\circ C \leq T_A \leq +85^\circ C$.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
On-Resistance of Switching Transistor	$R_{DS(ON)}$	—	3.8	7.0	Ω	$I_{SW} = 100\text{ mA}$, $V_{CS} = 75V$
Output Voltage Regulation	V_{CS}	75	80	85	V	$V_{DD} = 1.8V$ to $5.5V$
		73	—	87	V	—
Output Peak-to-Peak Voltage	$V_A - V_B$	150	160	170	V	$V_{DD} = 1.8V$ to $5.5V$
		146	—	174	V	—
Input Low Voltage (Turn Off)	V_{EN-L}	—	—	0.5	V	$V_{DD} = 1.8V$ to $5.5V$
Input High Voltage (Turn On)	V_{EN-H}	$V_{DD} - 0.5$	—	—	V	$V_{DD} = 1.8V$ to $5.5V$
Shutdown Current (Note 2)	I_{SD}	—	0.01	0.1	μA	$R_{SW} = \text{LOW}$; $R_{EL} = \text{LOW}$ $V_{DD} = 5.5V$
			—	0.5		
Input Supply Current	I_{VDD}	—	21	75	μA	$R_{SW} = \text{HIGH}$; $R_{EL} = \text{HIGH}$ $V_{CS} = 75V$; V_A , V_B OPEN
Boosted Supply Current	I_{CS}	—	200	400	μA	$R_{SW} = \text{HIGH}$; $R_{EL} = \text{HIGH}$ $V_{CS} = 75V$; V_A , V_B OPEN
Input Current Including Inductor Current	I_{IN}	—	28	—	mA	$V_{IN} = V_{DD} = 1.8V$. See (Figure 1-1)
$V_A - V_B$ Output Drive Frequency	f_{EL}	285	360	435	Hz	—
Switching Transistor Frequency	f_{SW}	53	66	79	kHz	—
Switching Transistor Duty Cycle	D	—	90	—	%	—

Note 1: Specification for packaged product only.

2: Shutdown current is defined as the sum of current going into pin 1, 5, and 6 when the device is disabled.

MIC4826

TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Storage Temperature Range	T_S	-65	—	+150	°C	—
Ambient Temperature	T_A	-40	—	+85	°C	—
Package Thermal Resistances						
Thermal Resistance 8-Pin MSOP	θ_{JA}	—	206	—	°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}).

Test Circuit

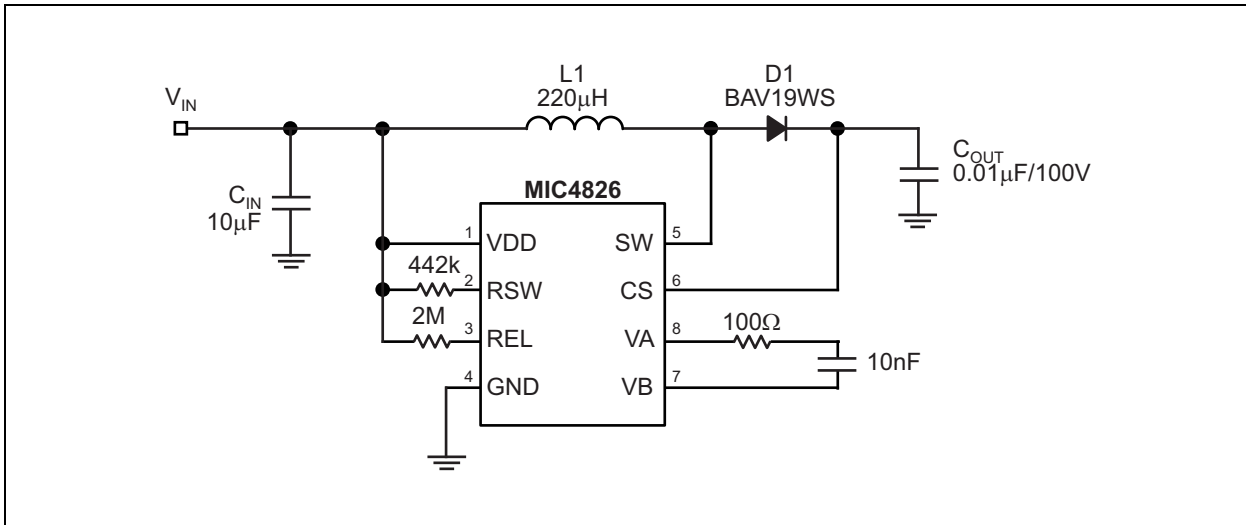


FIGURE 1-1: MIC4826 Test Circuit.

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.

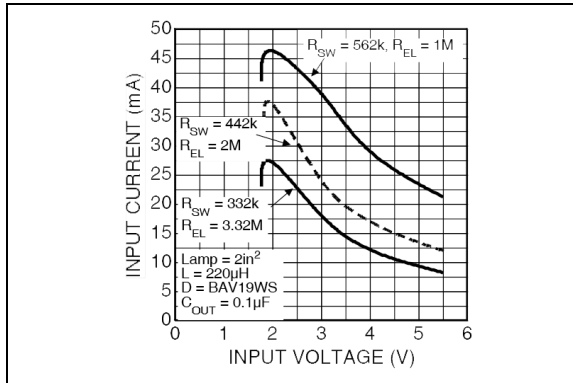


FIGURE 2-1: Total Input Current vs. Input Voltage.

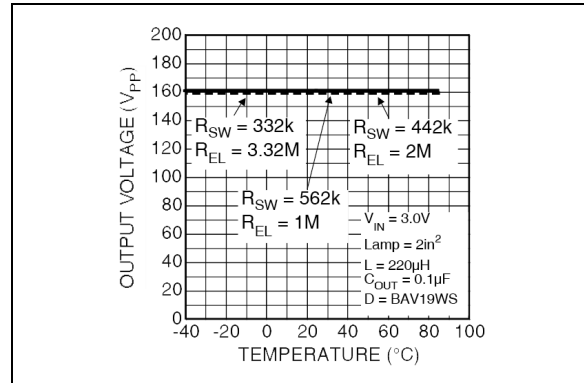


FIGURE 2-4: Output Voltage vs. Temperature.

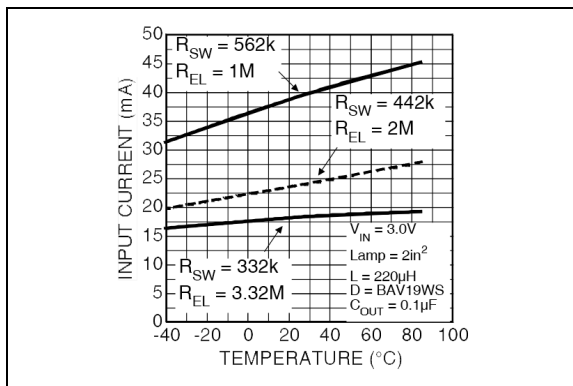


FIGURE 2-2: Total Input Current vs. Temperature.

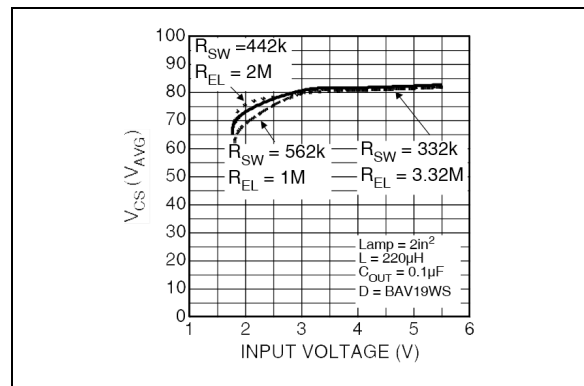


FIGURE 2-5: CS Voltage vs. Input Voltage.

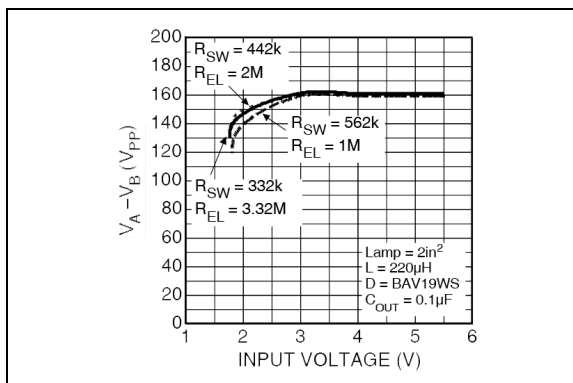


FIGURE 2-3: Output Voltage vs. Input Voltage.

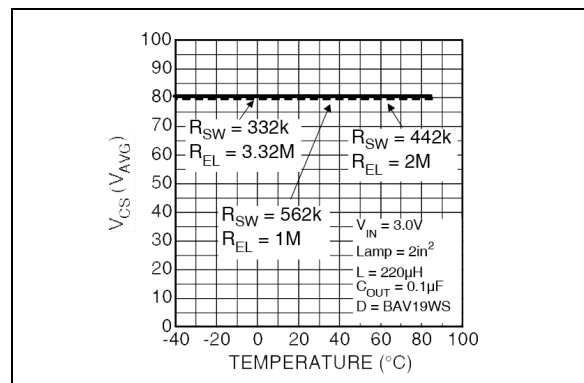


FIGURE 2-6: CS Voltage vs. Temperature.

MIC4826

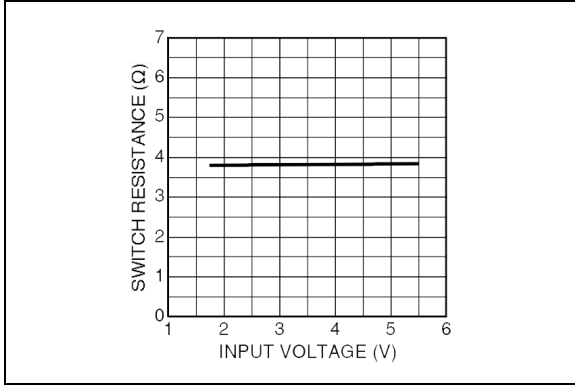


FIGURE 2-7: Switch Resistance vs. Input Voltage.

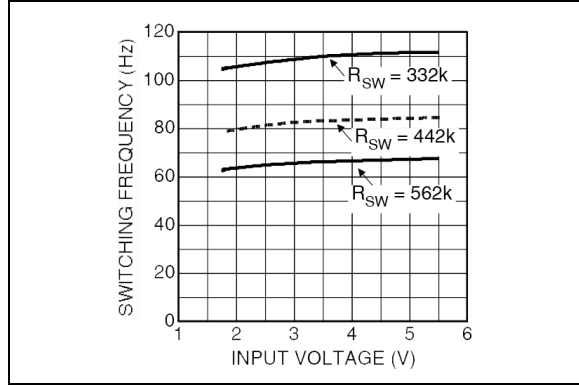


FIGURE 2-10: Switching Frequency vs. Input Voltage.

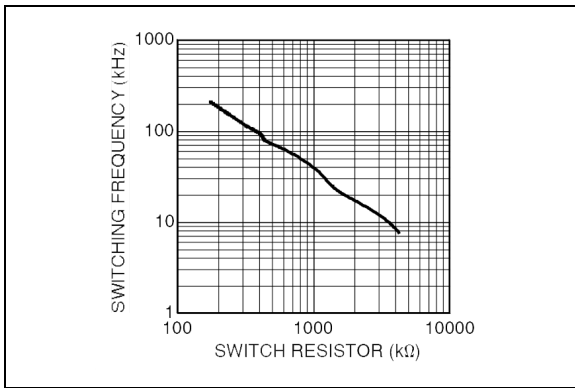


FIGURE 2-8: Switching Frequency vs. Switch Resistor.

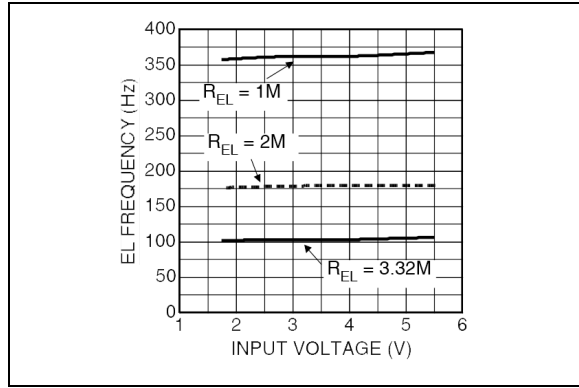


FIGURE 2-11: EL Frequency vs. Input Voltage.

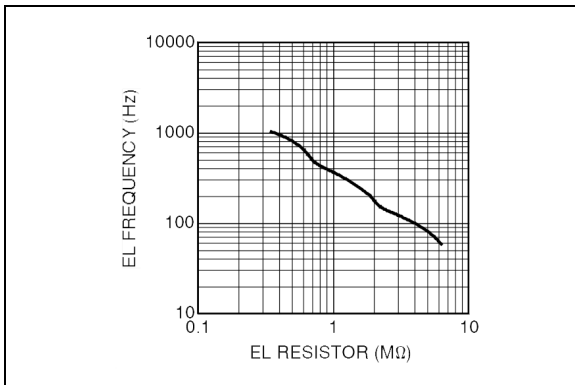


FIGURE 2-9: EL Frequency vs. EL Resistor.

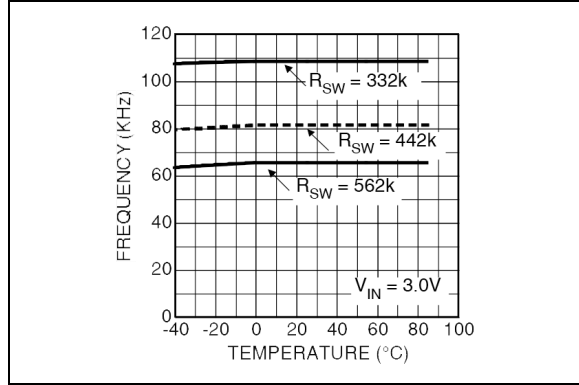


FIGURE 2-12: Switching Frequency vs. Temperature.

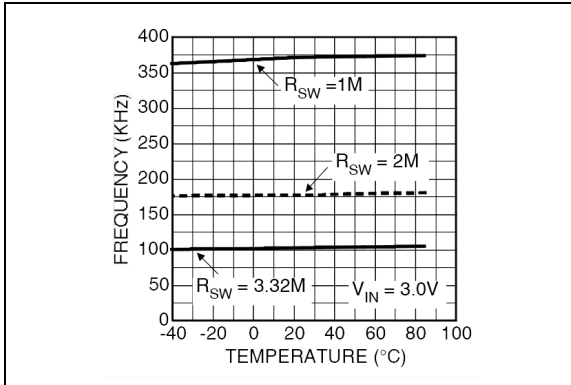


FIGURE 2-13: EL Frequency vs. Temperature.

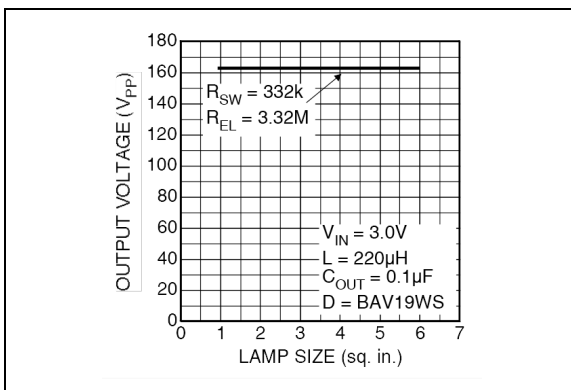


FIGURE 2-14: Output Voltage vs. Lamp Size.

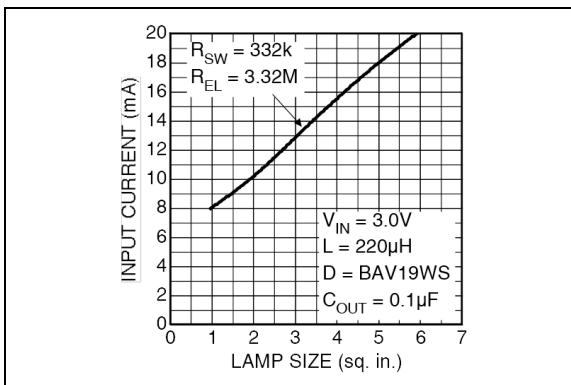


FIGURE 2-15: Total Input Current vs. Lamp Size.

MIC4826

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	VDD	Supply (Input): 1.8V to 5.5V for internal circuitry.
2	RSW	Switch Resistor (External Component): Set switch frequency of the internal power MOSFET by connecting an external resistor to VDD. Connecting the external resistor to GND disables the switch oscillator and shutdown the device.
3	REL	EL Resistor (External Component): Set EL frequency of the internal H-bridge driver by connecting an external resistor to V _{DD} . Connecting the external resistor to GND disables the EL oscillator.
4	GND	Ground return.
5	SW	Switch Node (Input): Internal high voltage power MOSFET drain.
6	CS	Regulated Boost Output (External Component): Connect to the output capacitor of the boost regulator and connect to the cathode of the diode.
7	VB	EL Output: Connect to one end of the EL lamp. Polarity is not important.
8	VA	EL Output: Connect to the other end of the EL lamp. Polarity is not important.

4.0 FUNCTIONAL DESCRIPTION

See [Section 5.0, Application Information](#) for component selection and pre-designed circuits.

4.1 Overview

The MIC4826 is a high voltage EL driver with an AC output voltage of 160V peak-to-peak capable of driving EL lamps up to 6 in². Input supply current for the MIC4826 is typically 21 μ A with a typical shutdown current of 10 nA. The high voltage EL driver has two internal oscillators to control the switching MOSFET and the H-bridge driver. Both of the internal oscillators' frequencies can be individually programmed through the external resistors to maximize the efficiency and the brightness of the lamps.

4.2 Regulation

Referring to [Figure 4-1](#), initially power is applied to V_{DD}. The internal feedback voltage is less than the reference voltage causing the internal comparator to go low which enables the switching MOSFET's oscillator.

When the switching MOSFET turns on, current flows through the inductor and into the switch. The switching MOSFET will typically turn on for 90% of the switching frequency. During the on time, energy is stored in the inductor.

When the switching MOSFET turns off, current flowing into the inductor forces the voltage across the inductor to reverse polarity. The voltage across the inductor rises until the external diode conducts and clamps the voltage at V_{OUT}+V_{D1}. The energy in the inductor is then discharged into the C_{OUT} capacitor. The internal comparator continues to turn the switching MOSFET on and off until the internal feedback voltage is above the reference voltage.

Once the internal feedback voltage is above the reference voltage, the internal comparator turns off the switching MOSFET's oscillator.

When the EL oscillator is enabled, V_A and V_B switch in opposite states to achieve a 160V peak-to-peak AC output signal. The external resistor that connects to the REL pin determines the EL frequency.

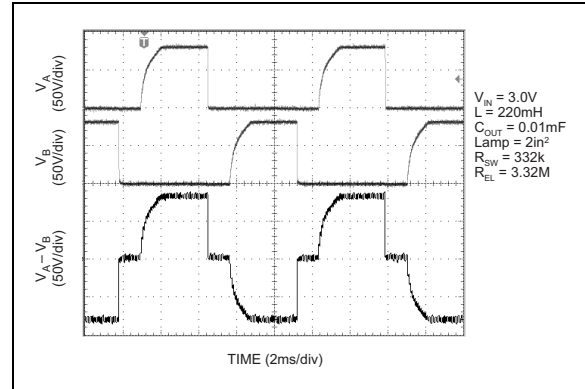


FIGURE 4-1: 108 Hz Typical Output Waveform.

4.3 Switching Frequency

The switching frequency of the converter is controlled via an external resistor between R_{SW} pin and V_{DD} pin of the device. The switching frequency increases as the resistor value decreases. For resistor value selections, see [Figure 2-8](#) or use equation [Equation 4-1](#). The switching frequency range is 8 kHz to 200 kHz, with an accuracy of $\pm 20\%$.

EQUATION 4-1:

$$f_{SW}(kHz) = \frac{36}{R_{SW}(M\Omega)}$$

4.4 EL Frequency

The EL lamp frequency is controlled via an external resistor connected between REL pin and V_{DD} pin of the device. As the lamp frequency increases, the resistor value decreases. For resistor value selections, see [Figure 2-9](#) or use equation [Equation 4-2](#). The EL frequency range is 60 Hz to 1000 Hz, with an accuracy of $\pm 20\%$.

EQUATION 4-2:

$$f_{EL}(Hz) = \frac{360}{R_{EL}(M\Omega)}$$

MIC4826

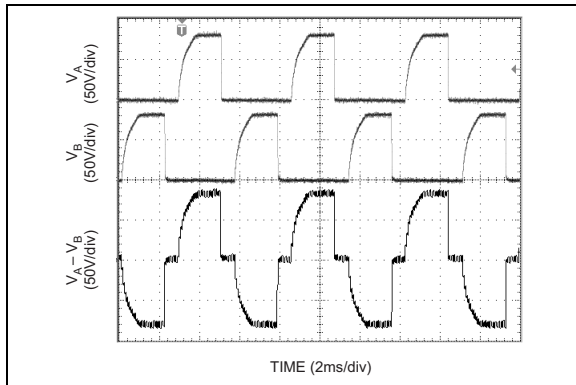


FIGURE 4-2: 180 Hz Output Waveform.

In general, as the EL lamp frequency increases, the amount of current drawn from the battery will increase. The color of the EL lamp and the intensity are dependent upon its frequency.

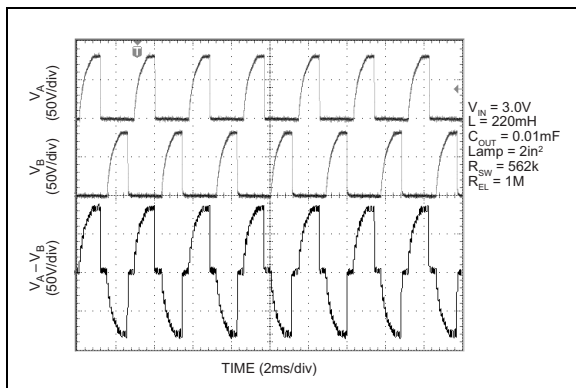


FIGURE 4-3: 360 Hz Output Waveform.

4.5 Enable Function

The enable function of the MIC4826 is implemented by switching the R_{SW} and R_{EL} resistor between ground and V_{DD} . When R_{SW} and R_{EL} are connected to ground, the switch and the EL oscillators are disabled; therefore the EL driver becomes disabled. When these resistors connect to V_{DD} , both oscillators will function and the EL driver is enabled.

5.0 APPLICATION INFORMATION

5.1 Inductor

In general, smaller value inductors, which can handle more current, are more suitable to drive larger size lamps. As the inductor value decreases, the switching frequency (controlled by R_{SW}) should be increased to avoid saturation or the input voltage should be increased. Typically, inductor values ranging from 220 μH to 560 μH can be used. Murata offers the LQH3C series up to 560 μH and LQH4C series up to 470 μH , with low DC resistance. A 220 μH Murata (LQH4C221K04) inductor is recommended for driving a lamp size of 3 square inches. It has a maximum DC resistance of 4.0 Ω .

5.2 Diode

The diode must have a high reverse voltage (100V) since the output voltage at the CS pin can reach up to 100V. A fast switching diode with lower forward voltage and higher reverse voltage (100V), such as BAV19WS, can be used to enhance efficiency.

5.3 Output Capacitor

Low ESR capacitors should be used at the regulated boost output (CS pin) of the MIC4826 to minimize the switching output ripple voltage. Selection of the capacitor value will depend upon the peak inductor current, inductor size, and the load. MuRata offers the GRM40 series with up to 0.015 μF at 100V, with a X7R temperature coefficient in 0805 surface mount package. Typically, values ranging from 0.01 μF to 0.1 μF at 100V can be used for the regulated boost output capacitor.

5.4 Pre-Designed Application Circuits

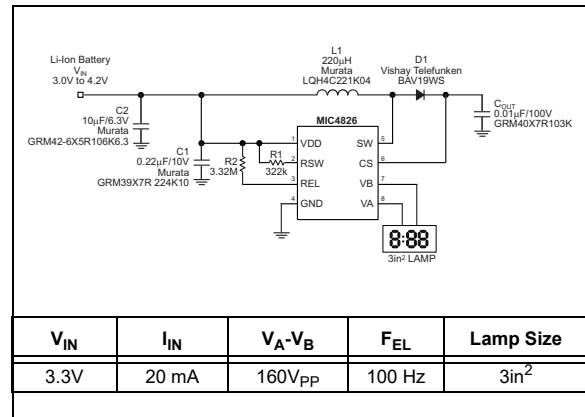


FIGURE 5-1: 100 Hz EL Driver for 3in² Lamp.

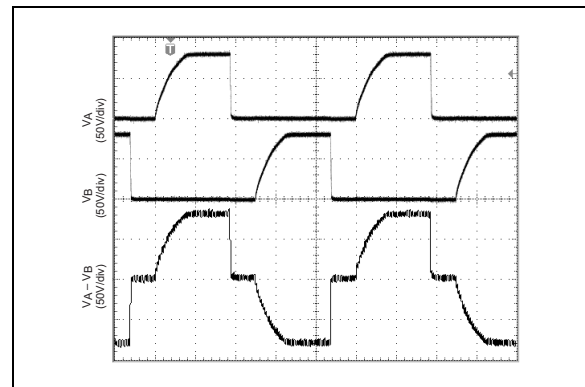


FIGURE 5-2: Typical Characteristics for 100 Hz EL Driver for 3in² Lamp.

MIC4826

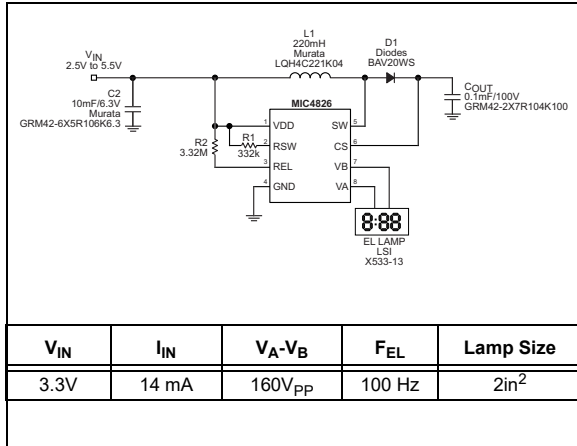


FIGURE 5-3: 100 Hz EL Driver for 2in² Lamp.

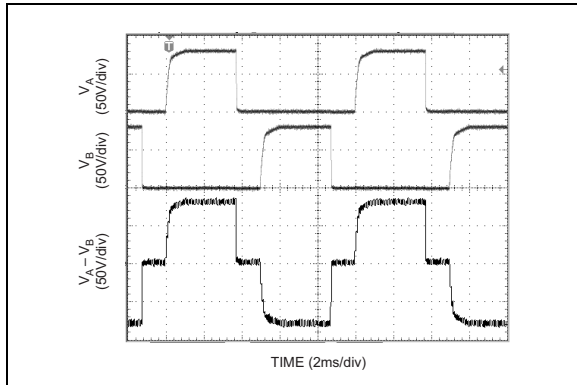


FIGURE 5-4: Typical Characteristics for EL Driver for 2in² Lamp with $C_S = 0.1 \mu\text{F}$.

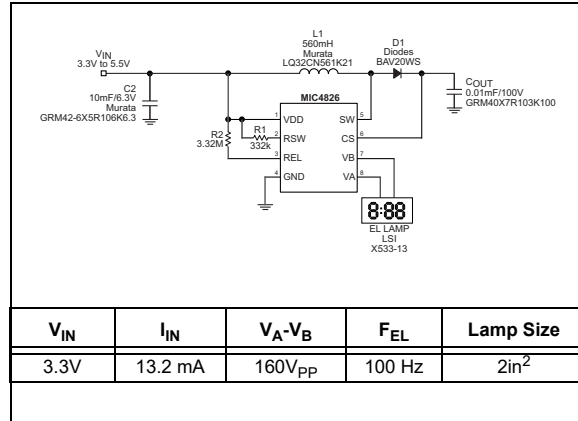


FIGURE 5-5: EL Driver for 2in² Lamp with 560 μF .

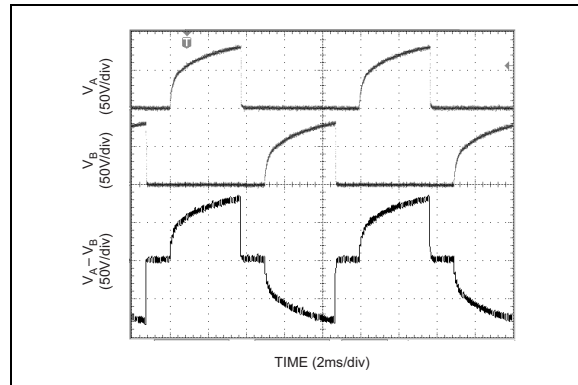


FIGURE 5-6: Typical Characteristics for EL Driver for 2in² Lamp with 560 μH Inductor.

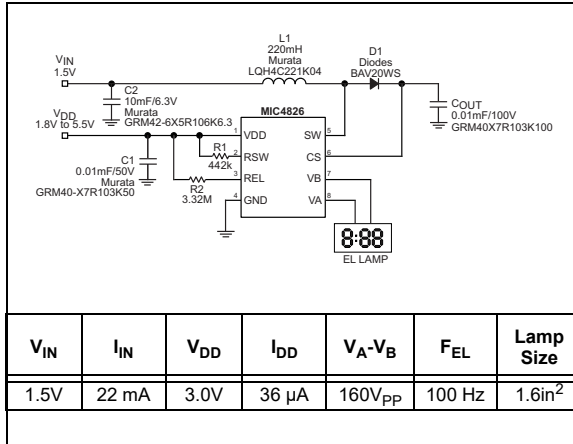


FIGURE 5-7: Typical for Split Power Supplies Applications.

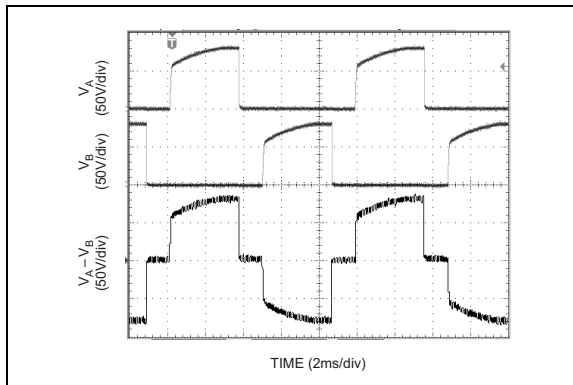


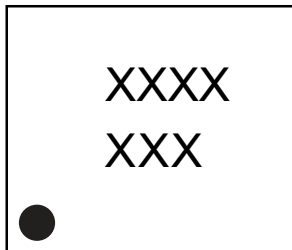
FIGURE 5-8: Typical Characteristics for Split Power Supplies Applications.

MIC4826

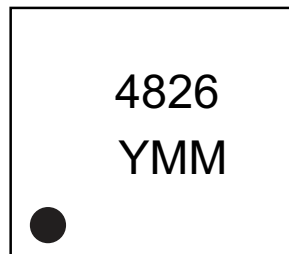
6.0 PACKAGING INFORMATION

6.1 Package Marking Information

8-Lead MSOP* (front)



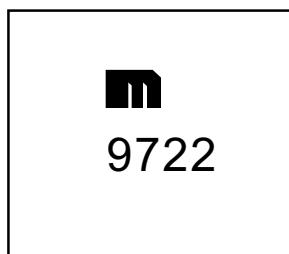
Example



8-Lead MSOP* (back)



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.	

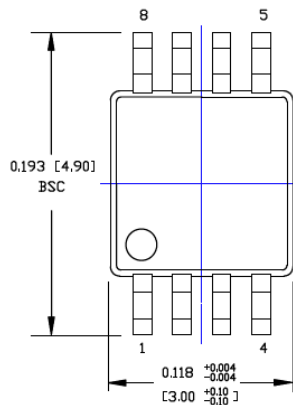
Note: If the full seven-character YYWWNNN code cannot fit on the package, the following truncated codes are used based on the available marking space:
6 Characters = YWWNNN; 5 Characters = WWNNN; 4 Characters = WNNN; 3 Characters = NNN;
2 Characters = NN; 1 Character = N

8-Lead MSOP Package Outline and Recommended Land Pattern

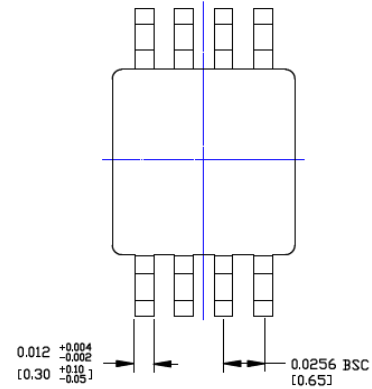
TITLE

8 LEAD MSOP PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

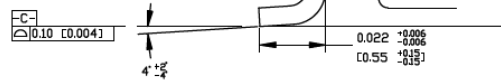
DRAWING #	MSOP-8LD-PL-1	UNIT	INCH [MM]
-----------	---------------	------	-----------



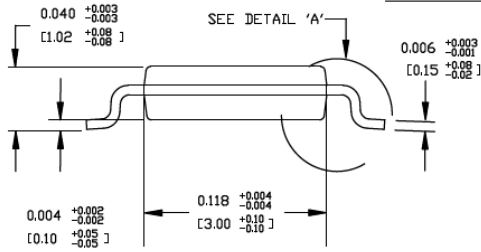
TOP VIEW



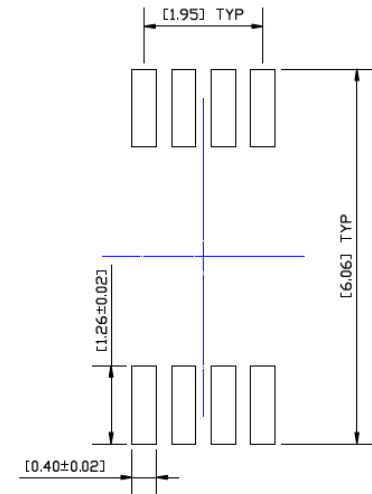
BOTTOM VIEW



DETAIL A



SIDE VIEW



RECOMMENDED LAND PATTERN

NOTES:

1. DIMENSIONS ARE IN INCHES [MM].
2. CONTROLLING DIMENSION: MM
3. DIMENSION DOES NOT INCLUDE MOLD FLASH OR PROTRUSIONS, EITHER OF WHICH SHALL NOT EXCEED 0.008 [0.20] PER SIDE.

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

MIC4826

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (January 2019)

- Converted Micrel document MIC4826 to Microchip data sheet DS20006134B.
- Minor text changes throughout.

Revision B (February 2022)

- Corrected package marking drawing in [Section 6.1, Package Marking Information](#) section.

MIC4826

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 NO.</u>	<u>X</u>	<u>XX</u>	<u>-XX</u>
Device	Junction Temperature Range	Package	Media Type
Device: MIC4826: Low Input Voltage, 160 V _{PP} Output Voltage, EL Driver	Junction Temperature Range: Y = -40°C to +85°C	Package: MM = 8-Lead MSOP	Media Type: Blank = 100/Tube TR = 2,500/Reel

Examples:

a) MIC4826YMM: Low Input Voltage, 160 V_{PP} Output Voltage, EL Driver, -40°C to +85°C Temperature Range, 8-Lead MSOP Package, 100/Tube

b) MIC4826YMM-TR: Low Input Voltage, 160 V_{PP} Output Voltage, EL Driver, -40°C to +85°C Temperature Range, 8-Lead MSOP Package, 2,500/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.

MIC4826

NOTES:

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

- 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, within operating specifications, and under normal conditions.
- Microchip values and aggressively protects its intellectual property rights. Attempts to breach the code protection features of Microchip product is strictly prohibited and may violate the Digital Millennium Copyright Act.
- 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. Microchip is committed to continuously improving the code protection features of our products.

This publication and the information herein may be used only with Microchip products, including to design, test, and integrate Microchip products with your application. Use of this information in any other manner violates these terms. Information regarding device applications is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. Contact your local Microchip sales office for additional support or, obtain additional support at <https://www.microchip.com/en-us/support/design-help/client-support-services>.

THIS INFORMATION IS PROVIDED BY MICROCHIP "AS IS". MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF NON-INFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE, OR WARRANTIES RELATED TO ITS CONDITION, QUALITY, OR PERFORMANCE.

IN NO EVENT WILL MICROCHIP BE LIABLE FOR ANY INDIRECT, SPECIAL, PUNITIVE, INCIDENTAL, OR CONSEQUENTIAL LOSS, DAMAGE, COST, OR EXPENSE OF ANY KIND WHATSOEVER RELATED TO THE INFORMATION OR ITS USE, HOWEVER CAUSED, EVEN IF MICROCHIP HAS BEEN ADVISED OF THE POSSIBILITY OR THE DAMAGES ARE FORESEEABLE. TO THE FULLEST EXTENT ALLOWED BY LAW, MICROCHIP'S TOTAL LIABILITY ON ALL CLAIMS IN ANY WAY RELATED TO THE INFORMATION OR ITS USE WILL NOT EXCEED THE AMOUNT OF FEES, IF ANY, THAT YOU HAVE PAID DIRECTLY TO MICROCHIP FOR THE INFORMATION.

Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

For information regarding Microchip's Quality Management Systems, please visit www.microchip.com/quality.

Trademarks

The Microchip name and logo, the Microchip logo, Adaptec, AnyRate, AVR, AVR logo, AVR Freaks, BesTime, BitCloud, CryptoMemory, CryptoRF, dsPIC, flexPWR, HELDO, IGLOO, JukeBlox, KeeLoq, Klear, LANCheck, LinkMD, maXStylus, maXTouch, MediaLB, megaAVR, Microsemi, Microsemi logo, MOST, MOST logo, MPLAB, OptoLyzer, PIC, picoPower, PICSTART, PIC32 logo, PolarFire, Prochip Designer, QTouch, SAM-BA, SenGenuity, SpyNIC, SST, SST Logo, SuperFlash, Symmetricom, SyncServer, Tachyon, TimeSource, tinyAVR, UNI/O, Vectron, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

AgileSwitch, APT, ClockWorks, The Embedded Control Solutions Company, EtherSynch, Flashtec, Hyper Speed Control, HyperLight Load, IntelliMOS, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus, ProASIC Plus logo, QuietWire, SmartFusion, SyncWorld, Temux, TimeCesium, TimeHub, TimePictra, TimeProvider, TrueTime, WinPath, and ZL are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, Augmented Switching, BlueSky, BodyCom, CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, Espresso T1S, EtherGREEN, GridTime, IdealBridge, In-Circuit Serial Programming, ICSP, INICnet, Intelligent Paralleling, Inter-Chip Connectivity, JitterBlocker, Knob-on-Display, maxCrypto, maxView, memBrain, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, NVM Express, NVMe, Omniscient Code Generation, PICDEM, PICDEM.net, PICkit, PICtail, PowerSmart, PureSilicon, QMatrix, REAL ICE, Ripple Blocker, RTAX, RTG4, SAM-ICE, Serial Quad I/O, simpleMAP, SimpliPHY, SmartBuffer, SmartHLS, SMART-I.S., storClad, SQL, SuperSwitcher, SuperSwitcher II, Switchtec, SynchroPHY, Total Endurance, TSHARC, USBCheck, VariSense, VectorBlox, VeriPHY, ViewSpan, WiperLock, XpressConnect, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

The Adaptec logo, Frequency on Demand, Silicon Storage Technology, Symmcom, and Trusted Time are registered trademarks of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2019 -2022, Microchip Technology Incorporated and its subsidiaries.

All Rights Reserved.

ISBN: 978-1-5224-9745-5



MICROCHIP

Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
<http://www.microchip.com/support>
Web Address:
www.microchip.com

Atlanta

Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Austin, TX

Tel: 512-257-3370

Boston

Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago

Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Dallas

Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit

Novi, MI
Tel: 248-848-4000

Houston, TX

Tel: 281-894-5983

Indianapolis

Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453
Tel: 317-536-2380

Los Angeles

Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608
Tel: 951-273-7800

Raleigh, NC

Tel: 919-844-7510

New York, NY

Tel: 631-435-6000

San Jose, CA

Tel: 408-735-9110
Tel: 408-436-4270

Canada - Toronto

Tel: 905-695-1980
Fax: 905-695-2078

ASIA/PACIFIC

Australia - Sydney
Tel: 61-2-9868-6733

China - Beijing
Tel: 86-10-8569-7000

China - Chengdu
Tel: 86-28-8665-5511

China - Chongqing
Tel: 86-23-8980-9588

China - Dongguan
Tel: 86-769-8702-9880

China - Guangzhou
Tel: 86-20-8755-8029

China - Hangzhou
Tel: 86-571-8792-8115

China - Hong Kong SAR
Tel: 852-2943-5100

China - Nanjing
Tel: 86-25-8473-2460

China - Qingdao
Tel: 86-532-8502-7355

China - Shanghai
Tel: 86-21-3326-8000

China - Shenyang
Tel: 86-24-2334-2829

China - Shenzhen
Tel: 86-755-8864-2200

China - Suzhou
Tel: 86-186-6233-1526

China - Wuhan
Tel: 86-27-5980-5300

China - Xian
Tel: 86-29-8833-7252

China - Xiamen
Tel: 86-592-2388138

China - Zhuhai
Tel: 86-756-3210040

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-3090-4444

India - New Delhi
Tel: 91-11-4160-8631

India - Pune
Tel: 91-20-4121-0141

Japan - Osaka
Tel: 81-6-6152-7160

Japan - Tokyo
Tel: 81-3-6880-3770

Korea - Daegu
Tel: 82-53-744-4301

Korea - Seoul
Tel: 82-2-554-7200

Malaysia - Kuala Lumpur
Tel: 60-3-7651-7906

Malaysia - Penang
Tel: 60-4-227-8870

Philippines - Manila
Tel: 63-2-634-9065

Singapore
Tel: 65-6334-8870

Taiwan - Hsin Chu
Tel: 886-3-577-8366

Taiwan - Kaohsiung
Tel: 886-7-213-7830

Taiwan - Taipei
Tel: 886-2-2508-8600

Thailand - Bangkok
Tel: 66-2-694-1351

Vietnam - Ho Chi Minh
Tel: 84-28-5448-2100

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4485-5910
Fax: 45-4485-2829

Finland - Espoo
Tel: 358-9-4520-820

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Garching
Tel: 49-8931-9700

Germany - Haan
Tel: 49-2129-3766400

Germany - Heilbronn
Tel: 49-7131-72400

Germany - Karlsruhe
Tel: 49-721-625370

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Germany - Rosenheim
Tel: 49-8031-354-560

Israel - Ra'anana
Tel: 972-9-744-7705

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Italy - Padova
Tel: 39-049-7625286

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Norway - Trondheim
Tel: 47-7288-4388

Poland - Warsaw
Tel: 48-22-3325737

Romania - Bucharest
Tel: 40-21-407-87-50

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

Sweden - Gothenberg
Tel: 46-31-704-60-40

Sweden - Stockholm
Tel: 46-8-5090-4654

UK - Wokingham
Tel: 44-118-921-5800
Fax: 44-118-921-5820