

N- and P-Channel Enhancement-Mode MOSFET Pair

Features

- Integrated Gate-to-Source Resistor
- Integrated Gate-to-Source Zener Diode
- Low Threshold
- Low On-Resistance
- Low Input Capacitance
- Fast Switching Speeds
- Free from Secondary Breakdown
- Low Input and Output Leakage
- Independent, Electrically Isolated N- and P-Channels
- 8-Lead Very Thin Plastic Dual Flat, No Lead, 6 x 5 mm VDFN Package

Applications

- High-Voltage Pulser
- Amplifiers
- Buffers
- Piezoelectric Transducer Drivers
- General-Purpose Line Drivers
- Logic-Level Interfaces

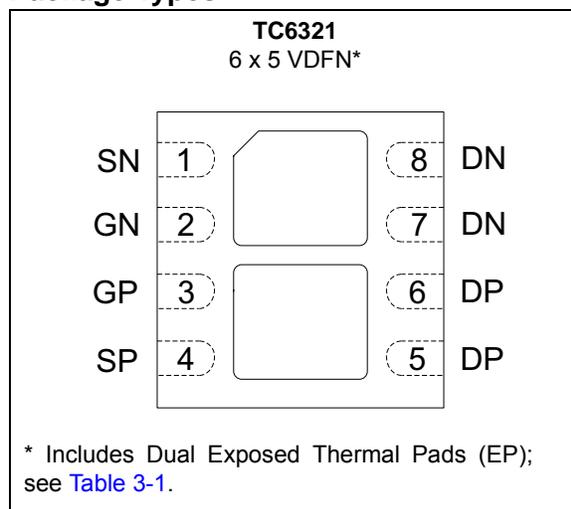
Description

The TC6321 consists of high-voltage, low-threshold N-channel and P-channel MOSFETs in an 8-Lead VDFN package. Both MOSFETs have integrated gate-to-source resistors and gate-to-source Zener diode clamps, which are desired for high-voltage pulser applications.

The TC6321 is a complimentary, high-speed, high-voltage, gate-clamped N- and P-channel MOSFET pair, which utilizes an advanced vertical DMOS structure and the well-proven silicon-gate manufacturing process. This combination produces a device with the power-handling capabilities of bipolar transistors and with the high-input impedance and positive temperature coefficient inherent in MOS devices. Characteristic of all MOS structures, this device is free from thermal runaway and thermally-induced secondary breakdown.

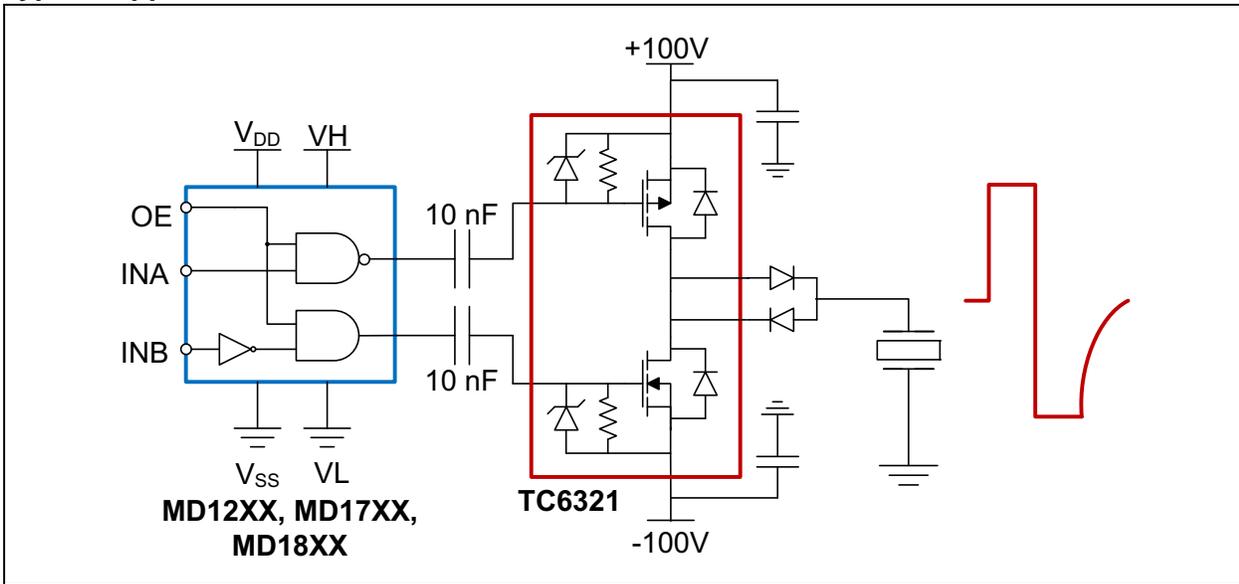
Vertical DMOS FETs are ideally suited to a wide range of switching and amplifying applications where very low threshold voltage, high breakdown voltage, high input impedance, low input capacitance and fast switching speeds are desired.

Package Types

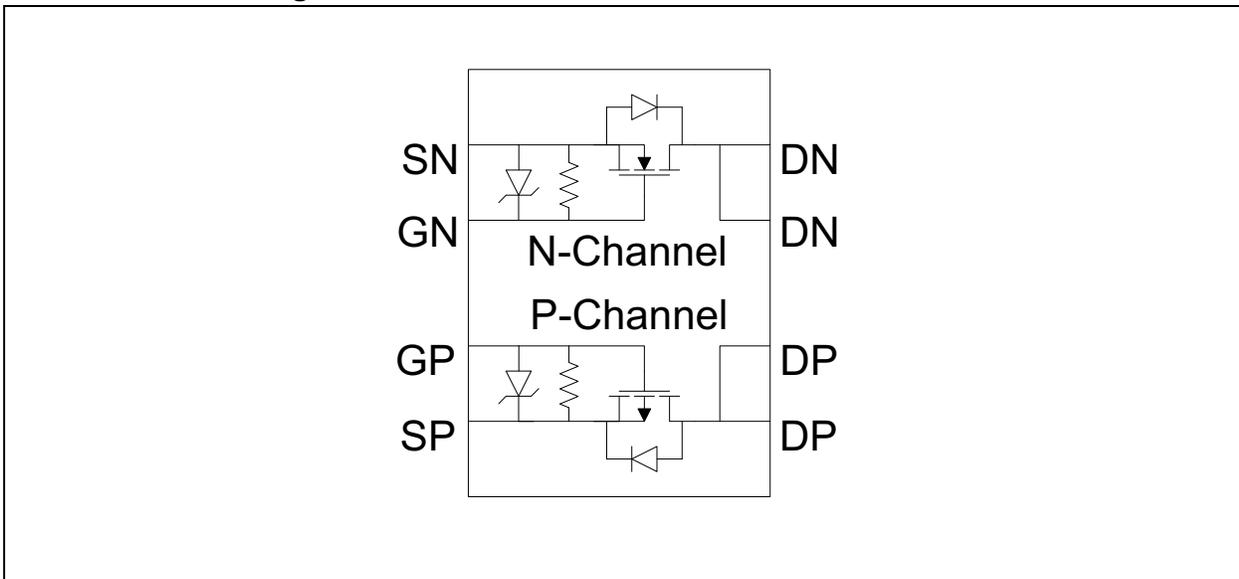


TC6321

Typical Application Circuit



Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Drain-to-Source Voltage.....	BV_{DSX}
Drain-to-Gate Voltage	BV_{DGX}
Operating and Storage Temperature.....	-55°C to +175°C

† **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 listings of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

N-CHANNEL DC AND AC ELECTRICAL CHARACTERISTICS

Unless otherwise noted, $T_A = T_J = +25^\circ\text{C}$.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
DC Parameters (Note 1)						
Drain-to-Source Breakdown Voltage	BV_{DSS}	200	—	—	V	$V_{GS} = 0\text{V}, I_D = 2.0\text{ mA}$
Gate Threshold Voltage	$V_{GS(th)}$	1.0	—	2.0	V	$V_{GS} = V_{DS}, I_D = 1.0\text{ mA}$
Change in $V_{GS(th)}$ with Temperature	$\Delta V_{GS(th)}$	—	—	-4.5	mV/°C	$V_{GS} = V_{DS}, I_D = 1.0\text{ mA}$ (Note 2)
Gate-to-Source Shunt Resistor	R_{GS}	10	—	50	k Ω	$I_{GS} = 100\text{ }\mu\text{A}$
Gate-to-Source Zener Voltage	V_{ZGS}	13.2	—	25	V	$I_{GS} = 2\text{ mA}$
Zero Gate Voltage Drain Current	I_{DSS}	—	—	10.0	μA	$V_{DS} = 200\text{V}$ $V_{GS} = 0\text{V}$
		—	—	1.0	mA	$V_{DS} = 200\text{V}, V_{GS} = 0\text{V}$ $T_J = +125^\circ\text{C}$ (Note 2)
On-State Drain Current	$I_{D(ON)}$	1.0	—	—	A	$V_{GS} = 4.5\text{V}, V_{DS} = 25\text{V}$
		2.0	—	—		$V_{GS} = 10\text{V}, V_{DS} = 25\text{V}$
Static Drain-to-Source On-State Resistance	$R_{DS(ON)}$	—	—	8.0	Ω	$V_{GS} = 4.5\text{V}, I_D = 150\text{ mA}$
		—	—	7.0		$V_{GS} = 10\text{V}, I_D = 1.0\text{A}$
Change in $R_{DS(ON)}$ with Temperature	$\Delta R_{DS(ON)}$	—	—	1.0	%/°C	$V_{GS} = 4.5\text{V}, I_D = 150\text{ mA}$ (Note 2)
AC Parameters (Note 2)						
Forward Transconductance	G_{FS}	400	—	—	mmho	$V_{GS} = 25\text{V}, I_D = 500\text{ mA}$
Input Capacitance	C_{ISS}	—	—	110	pF	$V_{GS} = 0\text{V}$ $V_{DS} = 25\text{V}$ $f = 1.0\text{ MHz}$
Common Source Output Capacitance	C_{OSS}	—	—	60		
Reverse Transfer Capacitance	C_{RSS}	—	—	23		
Turn-On Delay Time	$t_{d(ON)}$	—	—	10	ns	$V_{GS} = 10\text{V}$ $V_{DS} = 25\text{V}$ $I_D = 1.0\text{A}$ $R_{GEN} = 25\Omega$
Rise Time	t_r	—	—	15		
Turn-Off Delay Time	$t_{d(OFF)}$	—	—	20		
Fall Time	t_f	—	—	15		

Note 1: Unless otherwise stated, all DC parameters are 100% tested at +25°C. Pulse test: 300 μs pulse, 2% duty cycle.

2: Specification is obtained by characterization and is not 100% tested.

TC6321

N-CHANNEL DC AND AC ELECTRICAL CHARACTERISTICS (CONTINUED)

Unless otherwise noted, $T_A = T_J = +25^\circ\text{C}$.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Diode Parameters						
Diode Forward Voltage Drop	V_{SD}	—	—	1.8	V	$V_{GS} = 0\text{V}$, $I_{SD} = 500\text{ mA}$ (Note 1)
Reverse Recovery Time	t_{rr}	—	100	—	ns	$V_{GS} = 0\text{V}$, $I_{SD} = 500\text{ mA}$ $d_{iF}/dt = 25\text{ A}/\mu$ (Note 2)

Note 1: Unless otherwise stated, all DC parameters are 100% tested at $+25^\circ\text{C}$. Pulse test: 300 μs pulse, 2% duty cycle.

2: Specification is obtained by characterization and is not 100% tested.

P-CHANNEL DC AND AC ELECTRICAL CHARACTERISTICS

Unless otherwise noted, $T_A = T_J = +25^\circ\text{C}$.

Parameter	Sym.	Min.	Typ.	Max.	Unit	Condition
DC Parameters (Note 1)						
Drain-to-Source Breakdown Voltage	BV_{DSS}	-200	—	—	V	$V_{GS} = 0\text{V}$, $I_D = -2.0\text{ mA}$
Gate Threshold Voltage	$V_{GS(th)}$	-1.0	—	-2.4	V	$V_{GS} = V_{DS}$, $I_D = -1.0\text{ mA}$
Change in $V_{GS(th)}$ with Temperature	$\Delta V_{GS(th)}$	—	—	4.5	mV/ $^\circ\text{C}$	$V_{GS} = V_{DS}$, $I_D = -1.0\text{ mA}$ (Note 2)
Gate-to-Source Shunt Resistor	R_{GS}	10	—	50	k Ω	$I_{GS} = 100\text{ }\mu\text{A}$
Gate-to-Source Zener Voltage	V_{ZGS}	13.2	—	25	V	$I_{GS} = -2\text{ mA}$
Zero Gate Voltage Drain Current	I_{DSS}	—	—	-10.0	μA	$V_{DS} = 200\text{V}$, $V_{GS} = 0\text{V}$
		—	—	-1.0	mA	$V_{DS} = 200\text{V}$, $V_{GS} = 0\text{V}$ $T_J = +125^\circ\text{C}$, (Note 2)
On-State Drain Current	$I_{D(ON)}$	-1.0	—	—	A	$V_{GS} = -4.5\text{V}$, $V_{DS} = -25\text{V}$
		-2.0	—	—		$V_{GS} = -10\text{V}$, $V_{DS} = -25\text{V}$
Static Drain-to-Source On-State Resistance	$R_{DS(ON)}$	—	—	10	Ω	$V_{GS} = -4.5\text{V}$, $I_D = -150\text{ mA}$
		—	—	8.0		$V_{GS} = -10\text{V}$, $I_D = -1.0\text{A}$
Change in $R_{DS(ON)}$ with Temperature	$\Delta R_{DS(ON)}$	—	—	1.0	%/ $^\circ\text{C}$	$V_{GS} = -25\text{V}$, $I_D = -200\text{ mA}$ (Note 2)
AC Parameters (Note 2)						
Forward Transconductance	G_{FS}	400	—	—	mmho	$V_{GS} = -25\text{V}$, $I_D = -500\text{ mA}$
Input Capacitance	C_{ISS}	—	—	200	pF	$V_{GS} = 0\text{V}$ $V_{DS} = -25\text{V}$ $f = 1.0\text{ MHz}$
Common Source Output Capacitance	C_{OSS}	—	—	55		
Reverse Transfer Capacitance	C_{RSS}	—	—	30		
Turn-On Delay Time	$t_{d(ON)}$	—	—	10	ns	$V_{GS} = -10\text{V}$ $V_{DS} = -25\text{V}$ $I_D = -1.0\text{A}$ $R_{GEN} = 25\Omega$
Rise Time	t_r	—	—	15		
Turn-Off Delay Time	$t_{d(OFF)}$	—	—	20		
Fall Time	t_f	—	—	15		

Note 1: Unless otherwise stated, all DC parameters are 100% tested at $+25^\circ\text{C}$. Pulse test: 300 μs pulse, 2% duty cycle.

2: Specification is obtained by characterization and is not 100% tested.

P-CHANNEL DC AND AC ELECTRICAL CHARACTERISTICS (CONTINUED)

Unless otherwise noted, $T_A = T_J = +25^\circ\text{C}$.

Parameter	Sym.	Min.	Typ.	Max.	Unit	Condition
Diode Parameters						
Diode Forward Voltage Drop	V_{SD}	—	—	-1.8	V	$V_{GS} = 0\text{V}$, $I_{SD} = -500\text{ mA}$ (Note 1)
Reverse Recovery Time	t_{rr}	—	100	—	ns	$V_{GS} = 0\text{V}$, $I_{SD} = -500\text{ mA}$ $d_{iF}/dt = -25\text{ A}/\mu\text{s}$ (Note 2)

Note 1: Unless otherwise stated, all DC parameters are 100% tested at $+25^\circ\text{C}$. Pulse test: 300 μs pulse, 2% duty cycle.

2: Specification is obtained by characterization and is not 100% tested.

TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Operating Temperature	T_J	-40	—	+150	$^\circ\text{C}$	
Storage Temperature	T_A	-55	—	+175	$^\circ\text{C}$	
Thermal Package Resistances						
Thermal Resistance, 6x5 mm VDFN-8LD	θ_{JC}	—	1.43	—	$^\circ\text{C}/\text{W}$	
	θ_{JA}	—	34.4	—	$^\circ\text{C}/\text{W}$	

TC6321

NOTES:

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.

Note: Unless otherwise indicated, $T_A = T_J = 25^\circ\text{C}$.

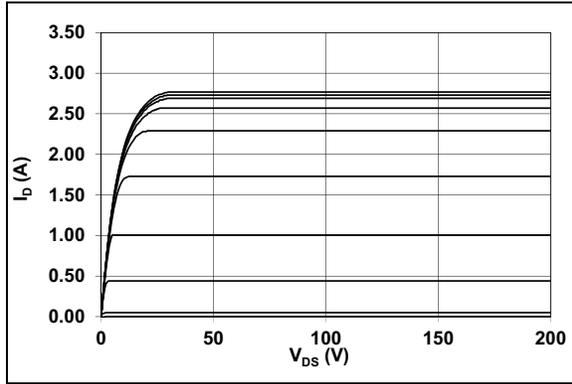


FIGURE 2-1: N-Channel I_D vs. V_{DS} (Output Characteristics).

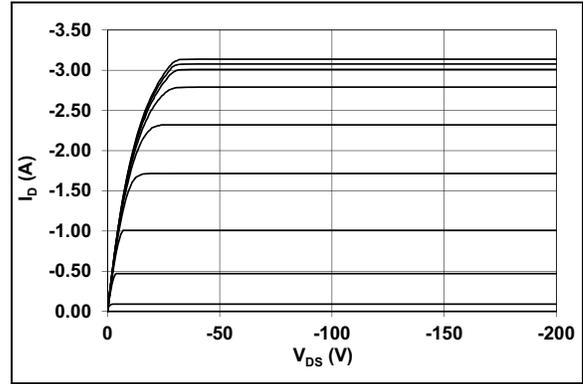


FIGURE 2-4: P-Channel I_D vs. V_{DS} (Output Characteristics).

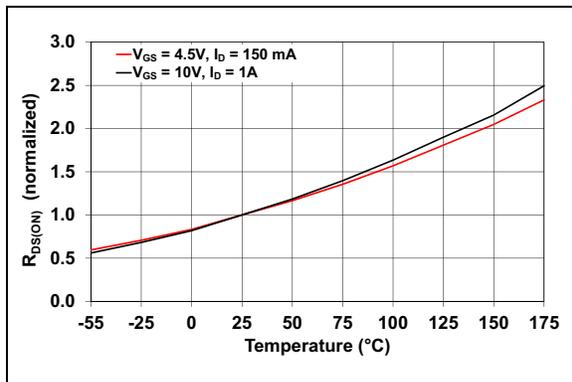


FIGURE 2-2: N-Channel On-Resistance vs. Temperature.

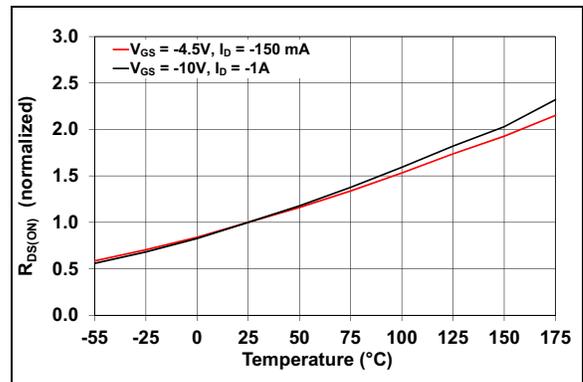


FIGURE 2-5: P-Channel On-Resistance vs. Temperature.

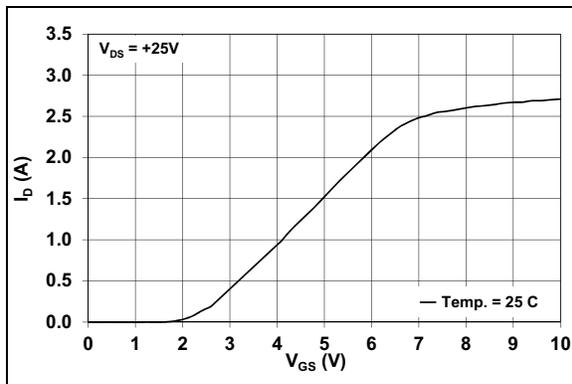


FIGURE 2-3: N-Channel I_D vs. V_{GS} .

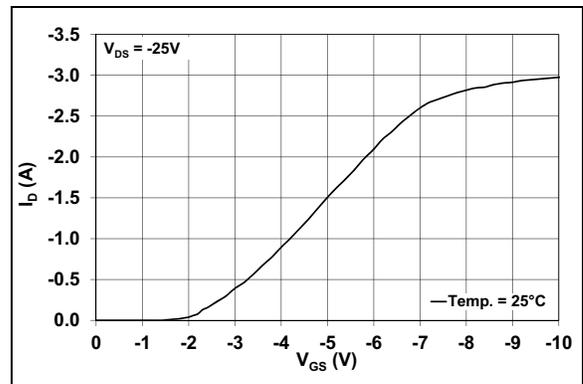


FIGURE 2-6: P-Channel I_D vs. V_{GS} .

TC6321

Note: Unless otherwise indicated, $T_A = T_J = 25^\circ\text{C}$.

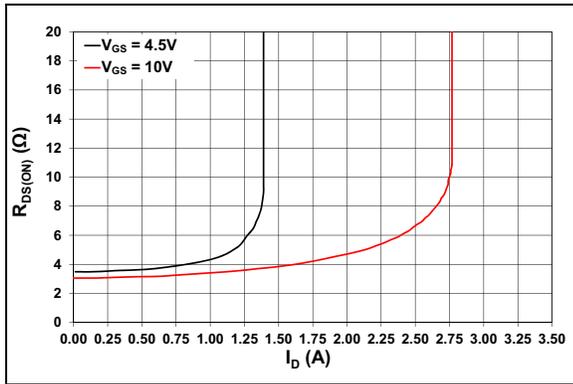


FIGURE 2-7: N-Channel On-Resistance vs. Drain Current.

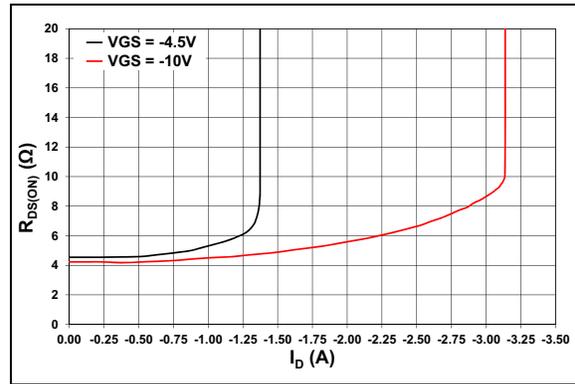


FIGURE 2-10: P-Channel On-Resistance vs. Drain Current.

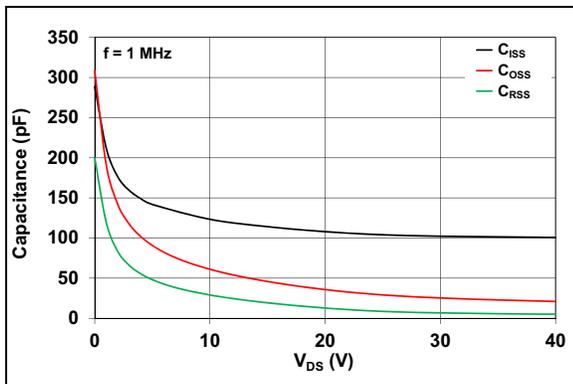


FIGURE 2-8: N-Channel Capacitance vs. Drain-to-Source Voltage.

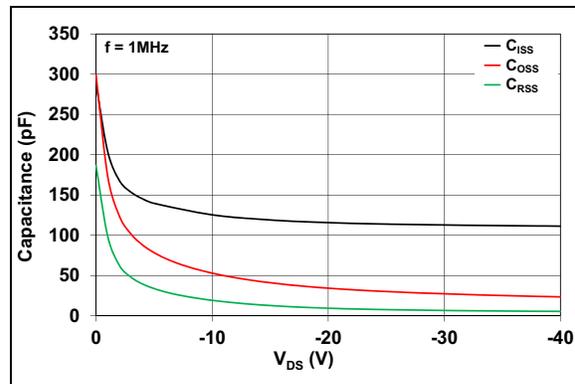


FIGURE 2-11: P-Channel Capacitance vs. Drain-to-Source Voltage.

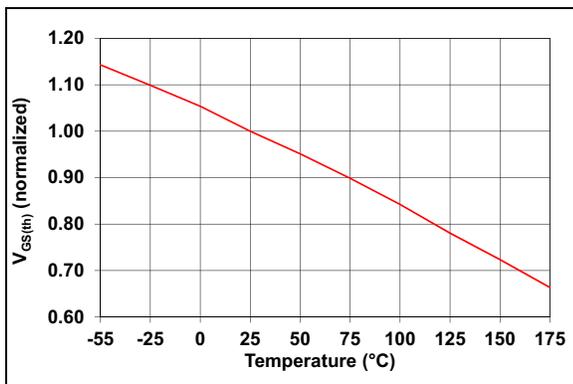


FIGURE 2-9: N-Channel $V_{GS(th)}$ vs. Temperature.

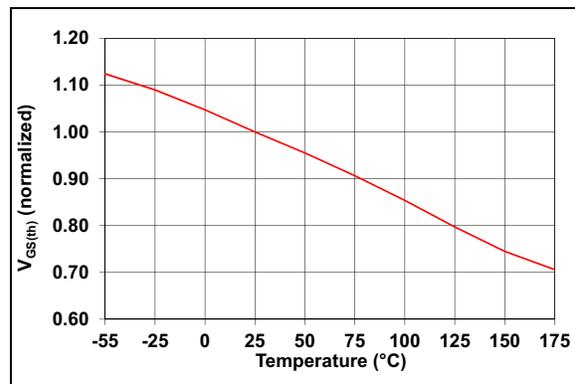


FIGURE 2-12: P-Channel $V_{GS(th)}$ vs. Temperature.

Note: Unless otherwise indicated, $T_A = T_J = 25^\circ\text{C}$.

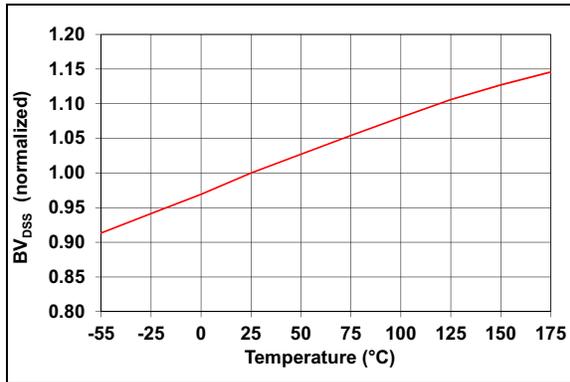


FIGURE 2-13: *N-Channel BV_{DSS} vs. Temperature.*

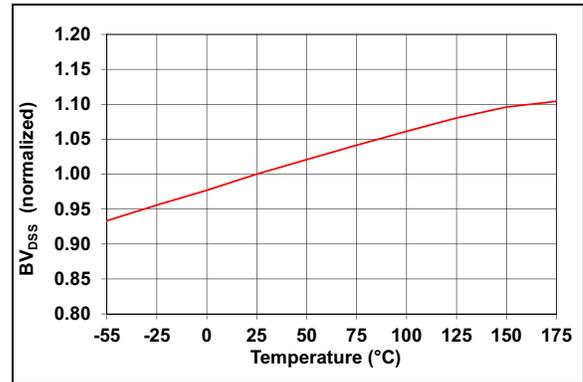


FIGURE 2-14: *P-Channel BV_{DSS} vs. Temperature.*

TC6321

NOTES:

3.0 PIN DESCRIPTION

The descriptions of the pins are listed in [Table 3-1](#).

TABLE 3-1: PIN FUNCTION TABLE

TC6321 6x5 VDFN	Name	Description
1	SN	Source N-Channel
2	GN	Gate N-Channel
3	GP	Gate P-Channel
4	SP	Source P-Channel
5, 6	DP	Drain P-Channel
7,8	DN	Drain N-Channel
9	EP	Dual Exposed Thermal Pads

TC6321

NOTES:

4.0 FUNCTIONAL DESCRIPTION

4.1 N-Channel Switching Waveforms and Test Circuit

Figure 4-1 shows the N-channel switching waveforms and test circuit.

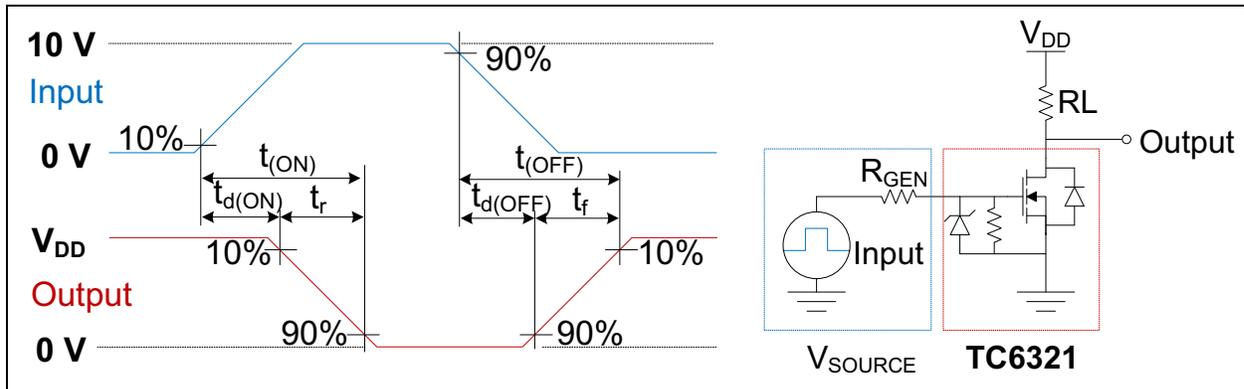


FIGURE 4-1: N-Channel Switching Waveforms and Test Circuit.

4.2 P-Channel Switching Waveforms and Test Circuit

Figure 4-2 shows the P-channel switching waveforms and test circuit.

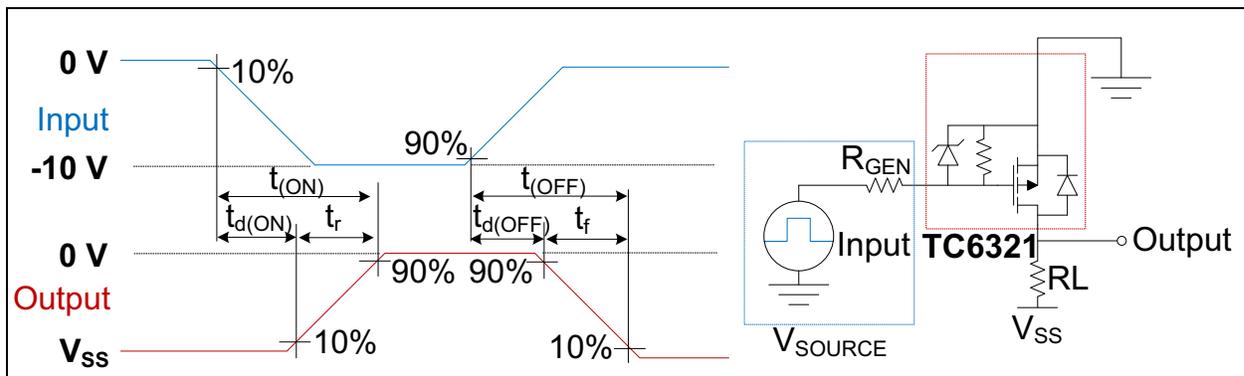


FIGURE 4-2: P-Channel Switching Waveforms and Test Circuit.

TC6321

NOTES:

5.0 APPLICATION INFORMATION

The TC6321 N- and P-MOSFET pair is designed for a wide range of switching and amplifying applications where high-voltage, high-current drive and fast switching speeds are required, especially for medical ultrasound applications.

A typical application pairs the TC6321 with any of MD12xx, MD17xx, or MD18xx ultrasound family MOSFET Drivers in order to form a high-speed and high-voltage (+/-100V 2.5A) pulser circuit. [Figure 5-1](#) illustrates the application circuit diagram for a two level pulser.

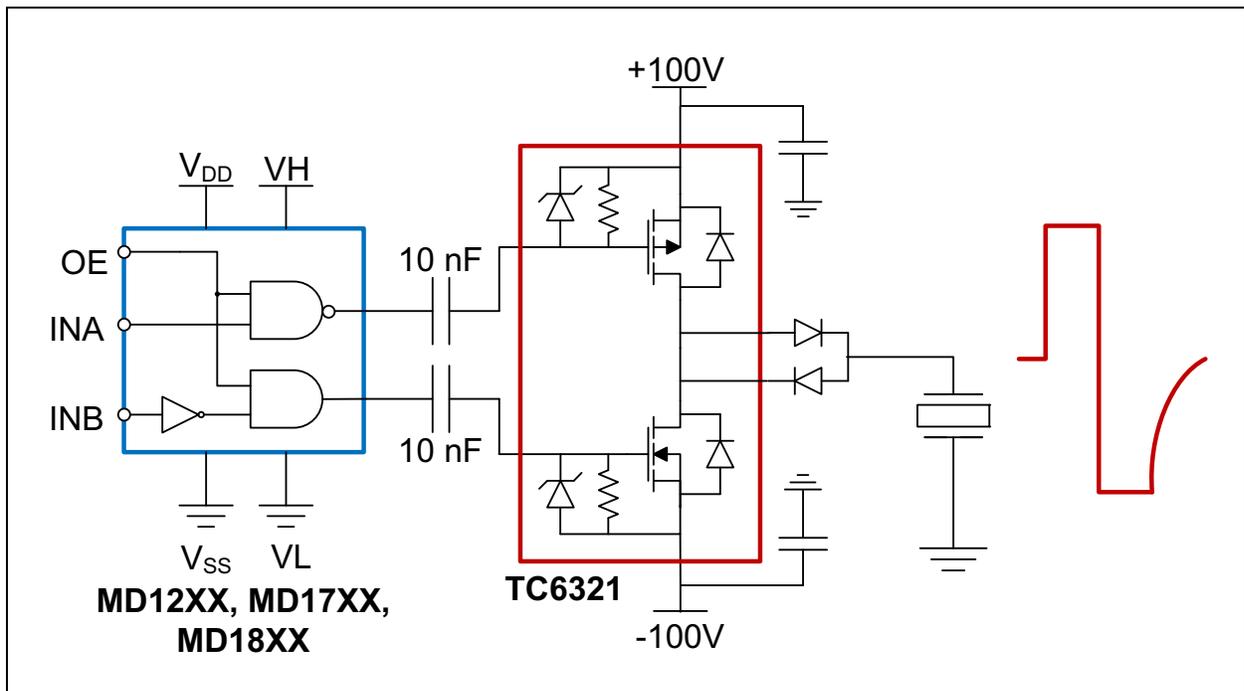


FIGURE 5-1: TC6321 - Application Circuit Diagram.

TC6321

NOTES:

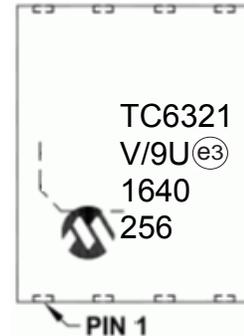
6.0 PACKAGING INFORMATION

6.1 Package Marking Information

8-Lead VDFN (6 x 5 mm)



Example



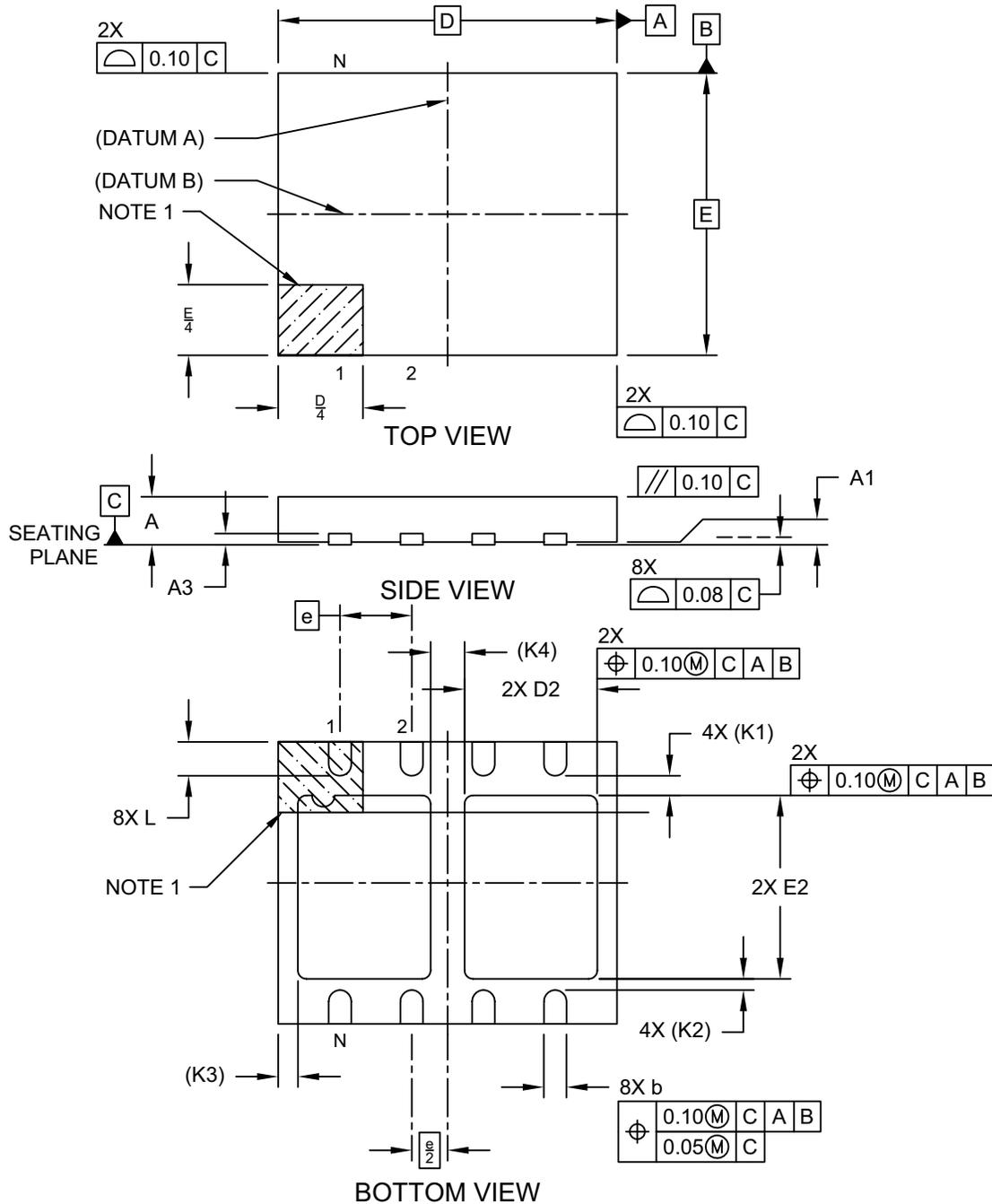
Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.

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.

TC6321

8-Lead Very Thin Plastic Dual Flat, No Lead (9U) - 6x5 mm Body [VDFN] With Dual Exposed Pads

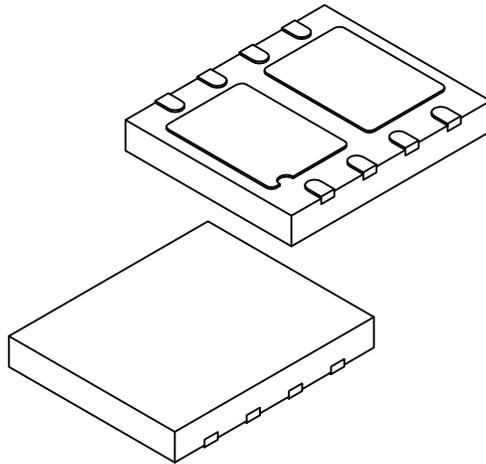
Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Microchip Technology Drawing C04-413A Sheet 1 of 2

8-Lead Very Thin Plastic Dual Flat, No Lead (9U) - 6x5 mm Body [VDFN] With Dual Exposed Pads

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



Dimension Limits	Units	MILLIMETERS		
		MIN	NOM	MAX
Number of Terminals	N	8		
Pitch	e	1.27 BSC		
Overall Height	A	0.80	0.85	0.90
Standoff	A1	0.00	0.02	0.05
Terminal Thickness	A3	0.20 REF		
Overall Length	D	6.00 BSC		
Exposed Pad Length (X2)	D2	2.25	2.35	2.45
Overall Width	E	5.00 BSC		
Exposed Pad Width (X2)	E2	3.15	3.25	3.35
Terminal Width	b	0.35	0.40	0.45
Terminal Length	L	0.55	0.60	0.65
Terminal to Exposed Pad (X4)	K1	0.35 REF		
Terminal to Exposed Pad (X4)	K2	0.20 REF		
Molded Package Edge to Exposed Pad	K3	0.35 REF		
Exposed Pad to Exposed Pad	K4	0.60 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.

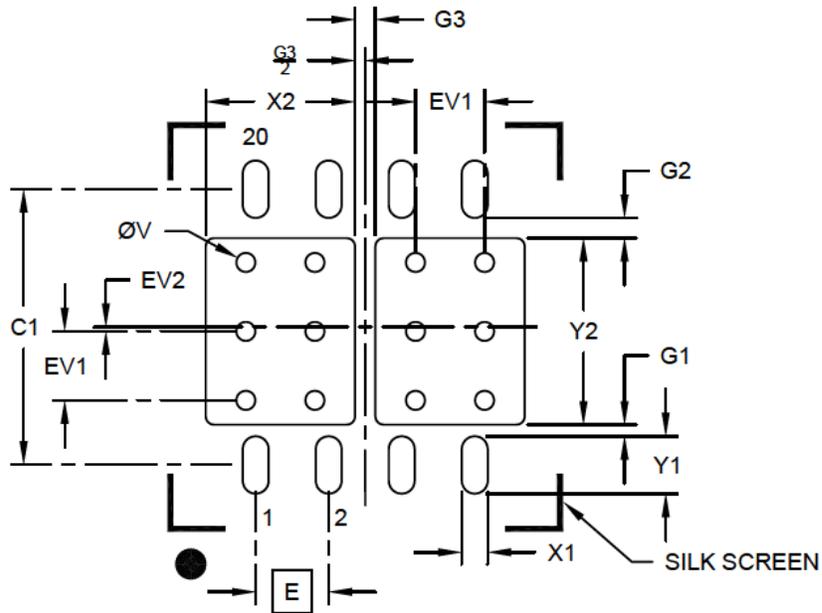
REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-413A Sheet 2 of 2

TC6321

8-Lead Very Thin Plastic Dual Flat, No Lead (9U) - 6x5 mm Body [VDFN] With Dual Exposed Pads

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



RECOMMENDED LAND PATTERN

Dimension Limits	Units	MILLIMETERS		
		MIN	NOM	MAX
Contact Pitch	E	1.27 BSC		
Optional Center Pad Width (X2)	X2			2.60
Optional Center Pad Length	Y2			3.25
Contact Pad Spacing	C1		4.80	
Contact Pad Width (X8)	X1			0.45
Contact Pad Length (X8)	Y1			0.80
Contact Pad to Center Pad (X4)	G1	0.20		
Contact Pad to Center Pad (X4)	G2	0.35		
Center Pad to Center Pad	G3		0.35	
Thermal Via Diameter (X12)	V		0.33	
Thermal Via Pitch	EV1		1.20	
Thermal Via Offset	EV2		0.08	

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 C04-2413A

APPENDIX A: REVISION HISTORY

Revision A (March 2017)

- Original Release of this Document.

TC6321

NOTES:

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

<u>PART NO.</u>	<u>X/</u>	<u>XX</u>
Device	Temperature	Package
<p>Device: TC6321T: N- and P-Channel Enhancement-Mode MOSFET Pair, Tape and Reel</p> <p>Temperature: V = -55°C to +175°C (Various temperature levels) ⁽¹⁾</p> <p>Package Type: 9U = Very Thin Plastic Dual Flat, No Lead, VDFN, 8-Lead, 6x5 mm Body, with Dual Exposed Pads</p>		<p>Examples:</p> <p>a) TC6321T-E/MQ: Tape and Reel, Various temperature levels, 8-LD VDFN package</p> <p>Note 1: Shipment of these devices may require an end-use/end-user certificate per SPI-43508.</p>

TC6321

NOTES:

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

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “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.

Information contained in this publication regarding device applications and the like 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. 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 ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. 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.

Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELoQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

**QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
= ISO/TS 16949 =**

Trademarks

The Microchip name and logo, the Microchip logo, AnyRate, AVR, AVR logo, AVR Freaks, BeaconThings, BitCloud, CryptoMemory, CryptoRF, dsPIC, FlashFlex, flexPWR, Heldo, JukeBlox, KEELoQ, KEELoQ logo, Kleer, LANCheck, LINK MD, maXStylus, maXTouch, MediaLB, megaAVR, MOST, MOST logo, MPLAB, OptoLyzer, PIC, picoPower, PICSTART, PIC32 logo, Prochip Designer, QTouch, RightTouch, SAM-BA, SpyNIC, SST, SST Logo, SuperFlash, tinyAVR, UNI/O, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

ClockWorks, The Embedded Control Solutions Company, EtherSynch, Hyper Speed Control, HyperLight Load, IntelliMOS, mTouch, Precision Edge, and Quiet-Wire 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, BodyCom, chipKIT, chipKIT logo, CodeGuard, CryptoAuthentication, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, EtherGREEN, In-Circuit Serial Programming, ICSP, Inter-Chip Connectivity, JitterBlocker, KleerNet, KleerNet logo, Mindi, MiWi, motorBench, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICKit, PICtail, PureSilicon, QMatrix, RightTouch logo, REAL ICE, Ripple Blocker, SAM-ICE, Serial Quad I/O, SMART-I.S., SQI, SuperSwitcher, SuperSwitcher II, Total Endurance, TSHARC, USBCheck, VariSense, ViewSpan, WiperLock, Wireless DNA, 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.

Silicon Storage Technology is a registered trademark 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.

© 2017, Microchip Technology Incorporated, All Rights Reserved.
ISBN: 978-1-5224-1396-7



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

Asia Pacific Office
Suites 3707-14, 37th Floor
Tower 6, The Gateway
Harbour City, Kowloon

Hong Kong
Tel: 852-2943-5100
Fax: 852-2401-3431

Australia - Sydney
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

China - Beijing
Tel: 86-10-8569-7000
Fax: 86-10-8528-2104

China - Chengdu
Tel: 86-28-8665-5511
Fax: 86-28-8665-7889

China - Chongqing
Tel: 86-23-8980-9588
Fax: 86-23-8980-9500

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

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

China - Hangzhou
Tel: 86-571-8792-8115
Fax: 86-571-8792-8116

China - Hong Kong SAR
Tel: 852-2943-5100
Fax: 852-2401-3431

China - Nanjing
Tel: 86-25-8473-2460
Fax: 86-25-8473-2470

China - Qingdao
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

China - Shanghai
Tel: 86-21-3326-8000
Fax: 86-21-3326-8021

China - Shenyang
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

China - Shenzhen
Tel: 86-755-8864-2200
Fax: 86-755-8203-1760

China - Wuhan
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

China - Xian
Tel: 86-29-8833-7252
Fax: 86-29-8833-7256

ASIA/PACIFIC

China - Xiamen
Tel: 86-592-2388138
Fax: 86-592-2388130

China - Zhuhai
Tel: 86-756-3210040
Fax: 86-756-3210049

India - Bangalore
Tel: 91-80-3090-4444
Fax: 91-80-3090-4123

India - New Delhi
Tel: 91-11-4160-8631
Fax: 91-11-4160-8632

India - Pune
Tel: 91-20-3019-1500

Japan - Osaka
Tel: 81-6-6152-7160
Fax: 81-6-6152-9310

Japan - Tokyo
Tel: 81-3-6880-3770
Fax: 81-3-6880-3771

Korea - Daegu
Tel: 82-53-744-4301
Fax: 82-53-744-4302

Korea - Seoul
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or
82-2-558-5934

Malaysia - Kuala Lumpur
Tel: 60-3-6201-9857
Fax: 60-3-6201-9859

Malaysia - Penang
Tel: 60-4-227-8870
Fax: 60-4-227-4068

Philippines - Manila
Tel: 63-2-634-9065
Fax: 63-2-634-9069

Singapore
Tel: 65-6334-8870
Fax: 65-6334-8850

Taiwan - Hsin Chu
Tel: 886-3-5778-366
Fax: 886-3-5770-955

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

Taiwan - Taipei
Tel: 886-2-2508-8600
Fax: 886-2-2508-0102

Thailand - Bangkok
Tel: 66-2-694-1351
Fax: 66-2-694-1350

EUROPE

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

Denmark - Copenhagen
Tel: 45-4450-2828
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

France - Saint Cloud
Tel: 33-1-30-60-70-00

Germany - Garching
Tel: 49-8931-9700

Germany - Haan
Tel: 49-2129-3766400

Germany - Heilbronn
Tel: 49-7131-67-3636

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: 47-7289-7561

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