
Excess Failure Rate Calculation Due to Neutron Flux with SiC MOSFETs and Schottky Diodes

<i>Author: Dennis Meyer Microchip Technology Inc.</i>

1.0 INTRODUCTION

Neutron-induced failures in power electronics are of concern in many higher reliability applications. The following document describes the process by which a decrease in lifetime expectancy can be estimated based upon the usage of the device. This estimation is most accurate at an altitude between sea level and 15,000 meters (50,000 feet). It is not applicable to space-based applications. The document is applicable to Microchip's family of SiC MOSFETs and diodes.

The experimental data in this document was taken from the CoolCAD report generated by CoolCAD Electronics LLC using Microchip devices. The report, dated March 3, 2019, is available upon request.

2.0 THE PHYSICAL MECHANISM

The process by which neutron-induced failures occur starts with high-energy particles entering the earth's atmosphere. Most of these particles are charged and are deflected by the earth's magnetic field. For this reason, neutron-induced failures are latitude dependent.

Particles entering the atmosphere are various nuclear fragments, a combination of protons, helium, heavier nuclear ions, high-energy gamma rays, etc. Various nuclear interactions take place early in the process of entering the atmosphere. Energy is spread to other gas atoms. This reduces the energy of individual interactions and increases the number of involved particles subject to the conservation of energy and momentum for the overall system.

Deeper in the atmosphere, the most significant reaction product is neutrons. Neutrons are not charged. This allows them to penetrate through any solid, without interaction with other atoms. Charged particles are subject to what is referred to as the Coulomb barrier. Neutrons, not being charged, can penetrate the barrier easily.

When a neutron penetrates through the semiconductor crystal it sometimes collides with a lattice nucleus, kicking the atom out of the lattice and ionizing the atom. Free particles result from this collision. These free particles ionize other atoms that are still fixed to the

atom. The result is a stream of holes/electron pairs along the path of the atom. If the free particles reach a voltage blocking region, they will accelerate toward their terminal atoms. Electrons to the positive side, holes to the negative side. As they accelerate they can generate more hole/electron pairs, multiplying their effect. By this multiplication, an avalanche is formed. Avalanching generates heat and can destroy the device.

The avalanche process is voltage dependent. The probability of a device capturing a neutron is dependent on the volume of the device. Five factors influence the probability of neutron-induced failure.

From most important to least, these are:

- Operating voltage in relation to breakdown voltage
- Altitude
- Device volume, with a slight dependence upon device structure
- Latitude
- Duty factor, the device must be blocking voltage for a failure to occur.

3.0 FIT RATE STATISTICS

The semiconductor industry normalizes the FIT (Failure in Time) rate at over 10^9 hours. For example, a FIT rate of one means that at an average of 10^9 device-hours of functioning, one device is expected to fail. It can also mean that out of 10^9 devices, it is expected that an average of one device would fail in one hour. Neutron-induced failures are a random occurrence that fit with this type of model. There are other sources of failures, which are not considered in this document:

- Infant mortality aspect of reliability curves.
- Extended usage outside of reliability curves.
- Failures during normal usage related to stress caused by humidity or heat. These stresses may be expressed as a FIT rate or a wear out mechanism. These depend on the way the stress results in failure.

Some properties of FIT rates:

- FIT rates can be added. In a system with multiple devices the FIT rate of the individual components are added.
- FIT rates can be summed over time. An average FIT rate can be assigned by weighing the FIT rate under various operating conditions multiplied by the fraction of time the device is at that operating condition. Neutron induced failures are an example of this. If an aircraft spends 30% of its time at an altitude of 10 km and 70% at 1 km, the profile adjusted FIT rate equals $0.3 \times \text{FIT}(10 \text{ Km}) + 0.7 \times \text{FIT}(1 \text{ Km})$.
- The system MTBF (Mean Time Between Failures) = $1 / \text{the system summed FIT rate}$.

Experimental FIT rate data presented in this document were measured with devices of the given voltage and type. The FIT rate is proportional to device volume. A correction factor is applied to scale from the measured device to the application device.

4.0 FIT RATE CALCULATION

There are many ways to calculate neutron flux density. This aspect is caused by many sources of information, variation of measured results and the overall complexity of the problem. The calculations in the following sections are described in order to provide some background information on the sources.

4.1 Latitude Dependence

IEC TS 62396-1 2006, section 5.3.4 provides neutron flux as a function of latitude. This was curve fit to a tanh function and normalized to a value of one, at a latitude of 45 degrees. 45 degrees is used to match the latitude of NASA (National Aeronautics and Space Administration) and Boeing altitude dependence measurements.

The latitude correction formula is:

EQUATION 1:

$$Flat_numb = 0.857 + 0.559 \times \tanh\left(\frac{latitude - 42}{11.5}\right)$$

The range of this function is roughly from 0.30 to 1.40, domain 0 to 90. The result is unitless. The function plots as follows:

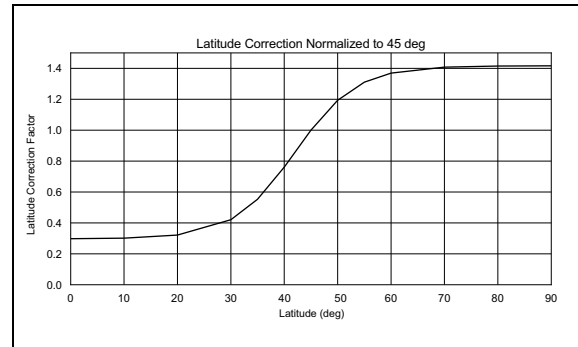


FIGURE 1: Latitude Correction Chart.

4.2 Altitude Dependence

There are two methods provided here to calculate altitude dependence. Both are only useful to about 15,000 meters (50,000 feet) due to high altitude effects. The first is by ABB referenced in ABB application notes 5SYA 2046-03 and 5SYA 2042-09.

EQUATION 2:

$$Flat_numb = \exp\left[\frac{1 - \left(1 - \frac{h}{44300}\right)^{5.26}}{0.143}\right]$$

The altitude "h" is measured in meters with a range from 0 to 15 km. This equation is unitless and is normalized to a value of one at sea level.

Equation 1 and Equation 2 can be used together to represent absolute flux density. For this, Equation 2 is modified with a multiplier of 13.3 to express flux density in measurement units of n/cm²/hr. This matched roughly with Boeing data presented in IEC TS 62396-1 2006. The resulting equation is presented below:

EQUATION 3:

$$Falt = 13.3 \times \exp\left[\frac{1 - \left(1 - \frac{h}{44300}\right)^{5.26}}{0.143}\right]$$

The altitude "h" is measured in meters with a range from 0 to 15 km. As was explained above, the measurement units of this resulting function are n/cm²/hr.

A second equation provided by CoolCAD follows. CoolCAD literature provides the equation in measurement units of $\text{n/cm}^2/\text{s}$ with the altitude in units of feet. The final form provided here is adjusted to measurement units of $\text{n/cm}^2/\text{hr}$ and altitude in meters:

EQUATION 4:

$$F_{alt} = 3600 \times 10^{0.2093 - 2.41511 \times \log 10(h \times 3.28) + 0.50386 \times \log 10(h \times 3.28) \times \log 10(h \times 3.28)}$$

The altitude "h" is measured in meters, which is immediately converted to feet with the 3.28 multiplier. This equation is discontinuous at zero. When calculating FIT below 300 meters it is recommended to use 300 meters.

The graphic below compares the Boeing simplified model presented in IEC TS 62396-1 with the two equations above by ABB and CoolCAD.

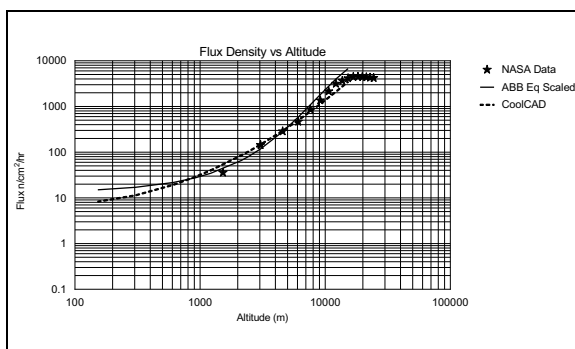


FIGURE 2: Flux Density vs. Altitude.

As can be seen in the NASA data, the flux density is very nonlinear above about 15,000 meters, which is the reason these equations should not be used in that case. The raw NASA data is available in IEC TS 62396-1.

4.3 Normalization of Neutron Flux Density

The process of FIT rate calculation starts by determining the effective neutron flux for an application. This can be done with a fixed position application with a known latitude and altitude. The product between Equation 1 and Equation 3 or Equation 4 can be used.

Automotive and aircraft applications are more complicated. A profile must be provided. Equation 1 together with Equation 3 or Equation 4 are used to calculate the neutron density for each element of the profile, multiplied by the fraction of time in that profile. The elements of the profile are then summed to yield the overall profile.

4.4 Using Normalized FIT Rate Charts

The following six sections present experimental data for one device from each of the three voltage MOSFETs and diodes categories. These devices are part of the Microchip second generation devices. Experimental data is presented together with an average FIT equation. The FIT rate graphics and equations presented are all normalized to a measurement unit of $13 \text{ n/cm}^2/\text{hr}$.

These graphics are applied as follows:

1. Determine which graphic applies by matching the voltage class of the device in the application with the appropriate graphic, [Section 4.4.1](#) – [Section 4.4.6](#). For example, when considering a MSC080SMA120J device select MSC040SMA120.
2. Determine the operating voltage in the application.
3. Multiply the FIT rate from the graphic by the volume correction table below the graphic to get the FIT rate for the specific device. This results in the FIT rate @ $13 \text{ n/cm}^2/\text{hr}$.
4. Multiply by the number of devices and the blocking voltage duty factor.
5. The result is the FIT rate for the application at a flux level of $13 \text{ n/cm}^2/\text{hr}$.

Based on the previous section, the average flux density is calculated by association with the application using Equation 1 together with Equation 3 or Equation 4.

The overall FIT rate = the device FIT rate calculated here $\times$ the application flux density divided by $13 \text{ n/cm}^2/\text{hr}$. That can all be done in one equation but doing so does not provide much insight into the calculation.

Example:

Assume an inverter operates at 1000V, 6.1 km altitude for eight hours a day, at 30 degrees latitude. It uses MSC025SMA120 in a half bridge arrangement.

- The graphic of [Section 4.4.5](#) puts the FIT rate for MSC040SMA120 at 2500.
- The die volume scaling factor to MSC025SMA120 is 1.6.
- The duty factor between the high side and low side transistors can be summed to one. If the desired FIT rate is per calendar time multiply by 8/24. If it is per operating time multiply by one.
- The latitude correction factor is approximately 0.35, per [Equation 1](#).
- The CoolCAD calculated flux density is approximately 500 n/cm²/hr, per [Equation 4](#) above at 6.1 km.

The resulting calculated FIT rate is:

$$2.5e2 \times 1.6 \times 0.35 \times (500/13) = 5384 \text{ failures per billion operating hours}$$

$$5384 \times (8/24) = 1795 \text{ failures per billion calendar hours}$$

4.4.1 700V DIODES

The following graphics expresses FIT as a function of operating voltage and altitude for MSC050SDA070B:

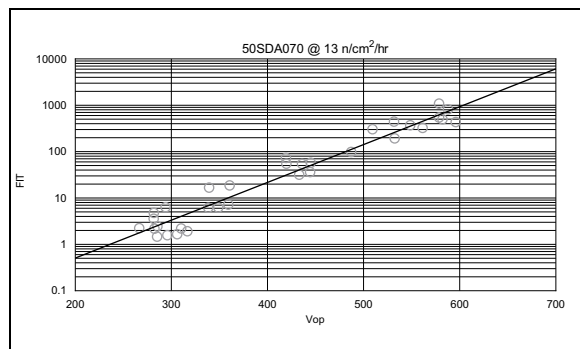


FIGURE 3: Operating Voltage and Altitude for MSC050SDA070B.

The curve fit shown above is:

$$FIT = \exp(0.0188 \times Vop - 4.44)$$

Use the following table to correct for die size:

Device	Volume Correction Factor
MSC010SDA070*	0.23
MSC030SDA070*	0.59
MSC050SDA070*	1
MSC2X50.,51 SDA070J	1 for each half, 2 total if paralleled
MSC2X100 SDA070J	2 for each half, 4 total if paralleled

4.4.2 1200V DIODES

The following graphics expresses FIT as a function of operating voltage and altitude for MSC050SDA120B.

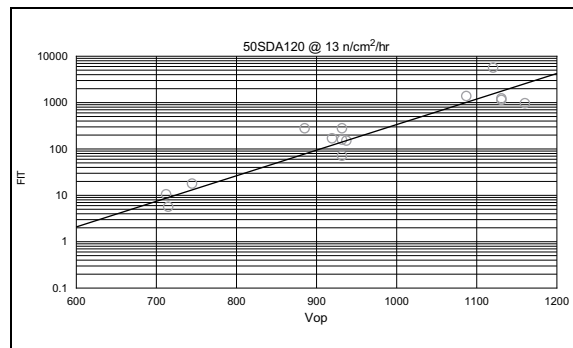


FIGURE 4: Operating Voltage and Altitude for MSC050SDA120B.

The curve fit shown above is:

$$FIT = \exp(0.0128 \times Vop - 6.88)$$

Use the following table to correct for die size:

Device	Volume Correction Factor
MSC010SDA120*	0.23
MSC015SDA120*	0.36
MSC020SDA120*	0.45
MSC030SDA120*	0.62
MSC050SDA120*	1
MSC2X50.,51SDA120J	1 for each half, 2 total if paralleled
MSC2X100 SDA120J	2 for each half, 4 total if paralleled

4.4.3 1700 DIODES

The following graphics expresses FIT as a function of operating voltage and altitude for MSC050SDA170B.

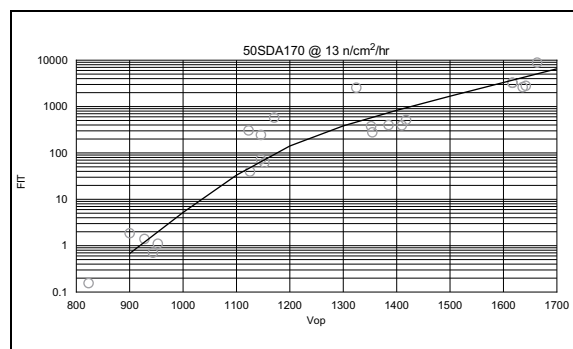


FIGURE 5: Operating Voltage and Altitude for MSC050SDA170B.

The curve fit shown above is:

$$\frac{I}{FIT} = \frac{I}{FIT1} + \frac{I}{FIT2}$$

Where:

$$FIT1 = \exp(0.00677 \times V_{op} - 2.72)$$

$$FIT2 = \exp(0.0211 \times V_{op} - 19.4)$$

Use the following table to correct for die size:

Device	Volume Correction Factor
MSC010SDA170*	0.23
MSC030SDA170*	0.59
MSC050SDA170*	1
MSC2X30.,31SDA170*	0.59 for each half, 1.18 total if paralleled
MSC2X50.,51SDA170*	1 for each half, 2 total if paralleled

4.4.4 700V MOSFETS

The following graphics expresses FIT as a function of operating voltage and altitude for MSC035SMA070B.

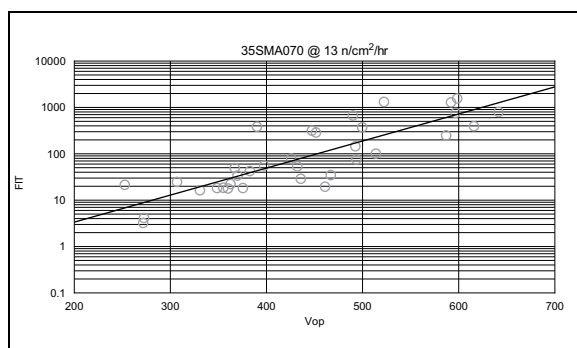


FIGURE 6: Operating Voltage and Altitude for MSC035SMA070B.

The curve fit shown above is:

$$FIT = \exp(0.0134 \times V_{ds} - 1.473)$$

Use the following table to correct for die size:

Device	Volume Correction Factor
MSC090SMA070*	0.46
MSC060SMA070*	0.64
MSC035SMA070*	1
MSC015SMA070*	2.1

4.4.5 1200V MOSFETS

The following graphics expresses FIT as a function of operating voltage and altitude for MSC040SMA120B.

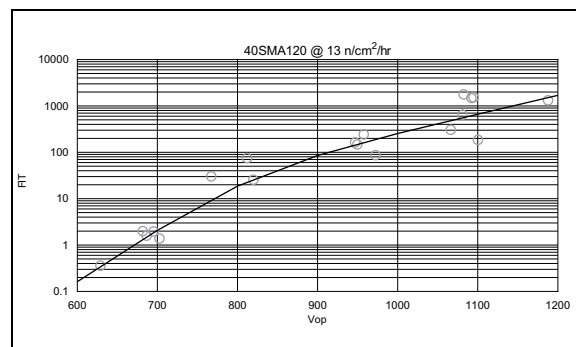


FIGURE 7: Operating Voltage and Altitude for MSC040SMA120B.

The curve fit shown above is:

$$\frac{I}{FIT} = \frac{I}{FIT1} + \frac{I}{FIT2}$$

Where:

$$FIT1 = \exp(0.0093 \times V_{ds} - 3.73)$$

$$FIT2 = \exp(0.0266 \times V_{ds} - 17.7)$$

Use the following table to correct for die size:

Device	Volume Correction Factor
MSC360SMA120*	0.19
MSC180SMA120*	0.31
MSC080SMA120*	0.60
MSC040SMA120*	1
MSC025SMA120*	1.60
MSC017SMA120*	1.60

4.4.6 1700V MOSFETS

The following graphics expresses FIT as a function of operating voltage and altitude for MSC035SMA170B.

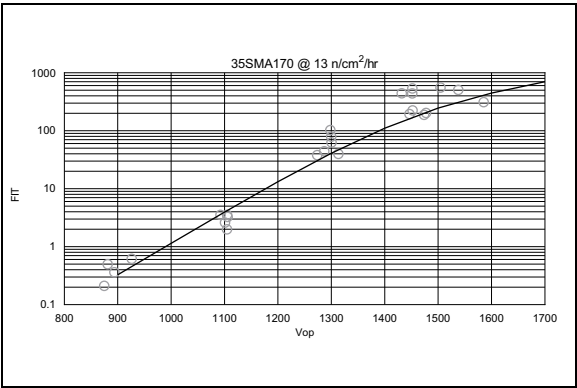


FIGURE 8: Operating Voltage and Altitude for MSC035SMA170B.

The curve fit shown above is:

$$\frac{1}{FIT} = \frac{1}{FIT1} + \frac{1}{FIT2}$$

Where:

$$FIT1 = \exp(0.0126 \times Vds - 12.4)$$
$$FIT2 = \exp(0.00326 \times Vds + 1.1)$$

Use the following table to correct for die size:

Device	Volume Correction Factor
MSC750SDA170*	0.115
MSC035SDA170*	1.0

REFERENCES

1. CoolCAD Report, CoolCAD Electronics LLC, March 2019.
2. Technical Specification IEC TS 62396-1, Section 5.3.4, 2006.
3. Application Note 5SYA 2046-03, ABB, 2019.
4. Application Note 5SYA 2042-09, ABB, 2019.

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, 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, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus, ProASIC Plus logo, Quiet-Wire, SmartFusion, SyncWorld, Temux, TimeCesium, TimeHub, TimePictra, TimeProvider, TrueTime, 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, Clockstudio, 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, IntelliMOS, Inter-Chip Connectivity, JitterBlocker, Knob-on-Display, KoD, maxCrypto, maxView, memBrain, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, 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, SQI, SuperSwitcher, SuperSwitcher II, Switchtec, SynchroPHY, Total Endurance, Trusted Time, 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, and Symmcom 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.

© 2022, Microchip Technology Incorporated and its subsidiaries.

All Rights Reserved.

ISBN: 978-1-6683-0780-9

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