AN14423

基于FRDM-MCXN947的风扇异常检测设备上训练

第1.0版—2024年9月10日 应用笔记

文档信息

信息	内容
关键词	AN14423、FRDM-MCXN947、MCXN947、风扇异常检测、支持向量机（SVM）
摘要	本文介绍了如何准备软件环境并搭建硬件以使用FRDM-MCXN947进行风扇异常检测。

1 介绍

本文介绍了如何准备软件环境并搭建硬件以使用FRDM-MCXN947进行风扇异常检测。本演示使用风扇上的加速度传感器来实时监测风扇是否正常运行。该应用程序由单类支持向量机（SVM）模型提供支持，该模型支持设备上训练和实时推理。

1.1 SVM介绍

SVM是一种强大的机器学习算法，因其出色的性能和低计算量需求而备受青睐。它还只需要少量样本进行训练。

SVM用于二元分类、多元分类、回归和异常检测（单类SVM）。

1.2 要求

硬件要求

- MCX N Freedom开发板
  FRDM-MCXN947产品信息|恩智浦
- LCD扩展板LCD-PAR-S035
  LCD-PAR-S035产品信息|恩智浦
- 加速度传感器板ACCEL-4-CLICK
  Accel 4 Click (mikroe.com)
- USB风扇
- USB Type C线
- 双面胶带
- 一个亚克力或其他坚固材料制成的底座（可选）。

软件要求

- IDE：MCUXpresso v 11.9.0
- SDK：FRDM-MCXN947 v 2.14
- Windows操作系统（本上手操作中使用的是Windows 10操作系统）

1.3 系统概述

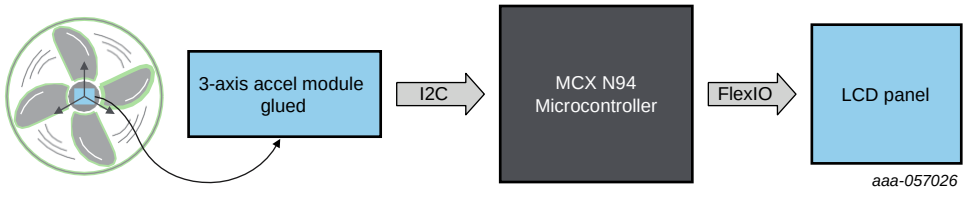

图1. 系统框架

在本演示中，加速度传感器通过双面胶带固定在风扇上。MCX控制器读取传感器数据，计算结果，并通过FlexIO将结果显示在LCD面板上。整个系统如图1所示。

该算法采用SVM模型来预测传感器的读数并确定风扇的状态。算法如图2所示。

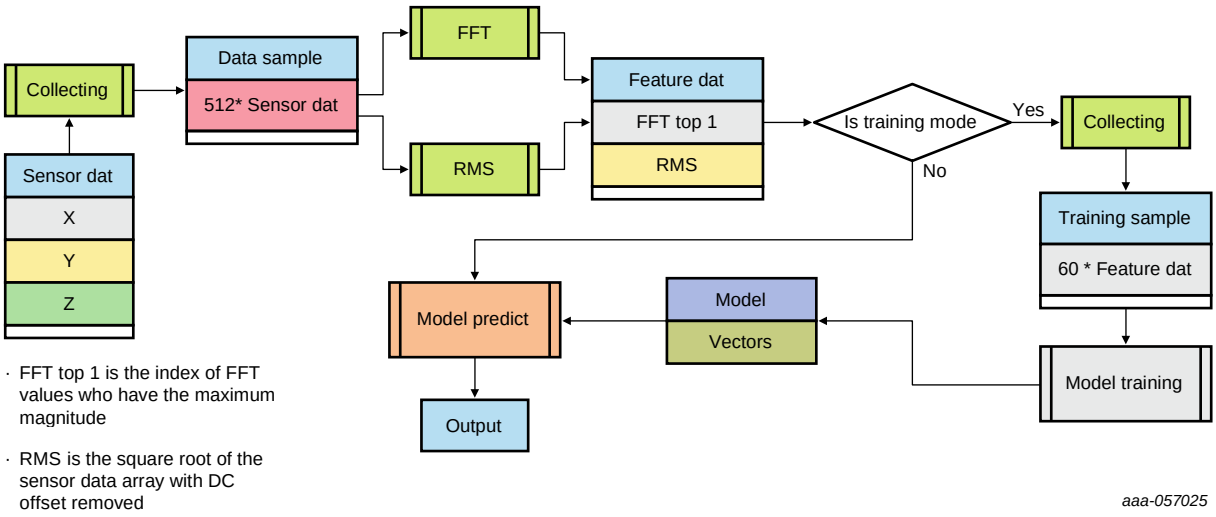

图2. 算法

2 硬件设置

本节介绍硬件的连接。

2.1 组件

需要以下组件：

- FRDM-MCXN947
- LCD扩展板——LCD-PAR-S035
- 加速度传感器：ACCEL-4-CLICK
- USB风扇
- （可选）一个尺寸为28cm × 24cm的底座平台，可以采用亚克力或其他坚固材料制成。由于加速度传感器比较灵敏，请确保风扇在稳定的环境中工作。

2.2 环境的搭建

要连接所有组件，请执行以下步骤：

1. 将LCD扩展板连接到FRDM开发板上。

图3. 将LCD连接到FRDM开发板

2. 将传感器连接到开发板上。

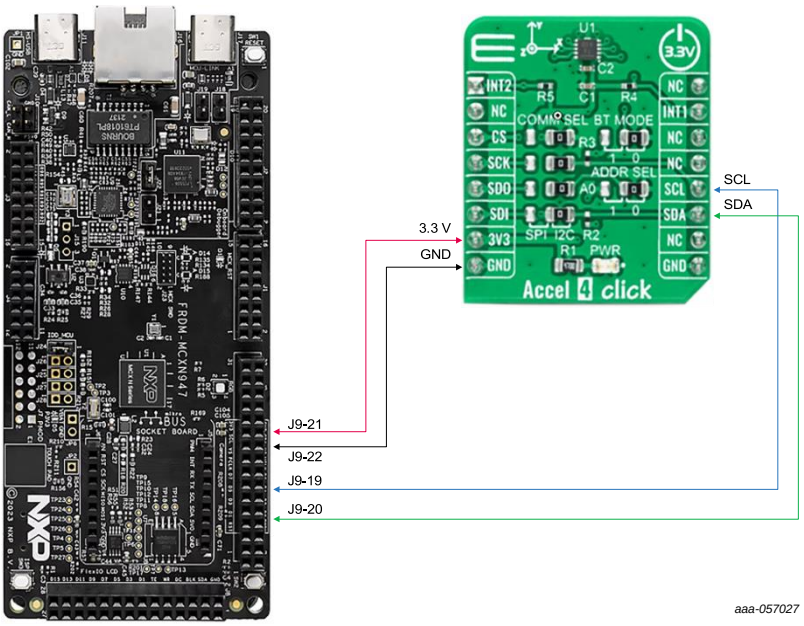

图4. 连接传感器

3. 使用双面胶带将传感器粘贴到风扇上。

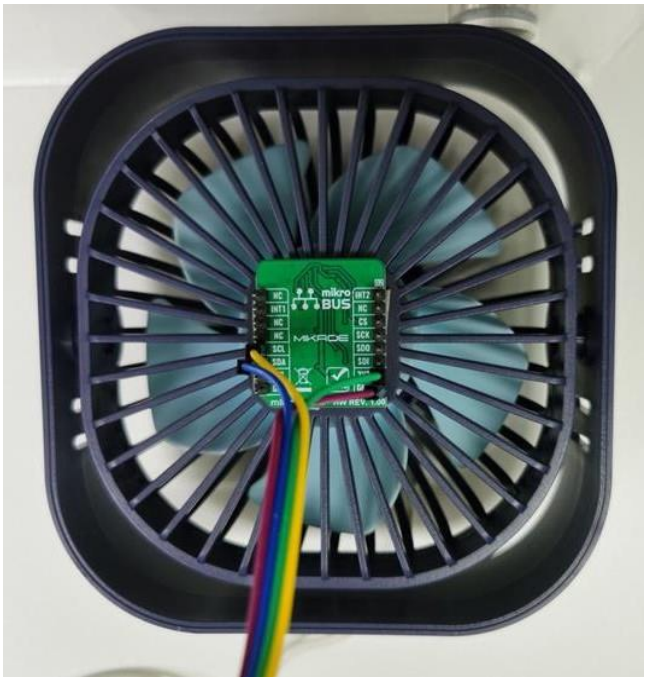

图5. 将传感器粘贴到风扇上

4. 使用双面胶带将主板和风扇固定在底座上。

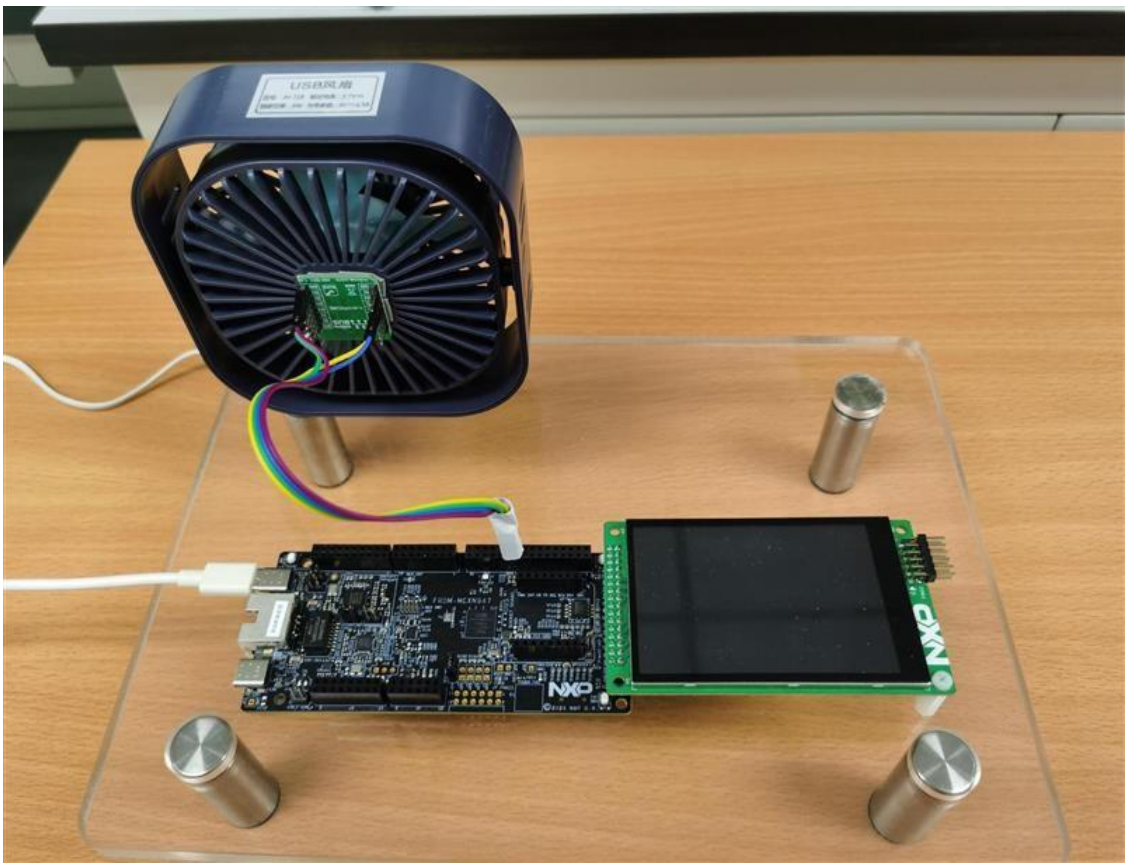

图6. 将主板和风扇固定在底座上

3 软件设置

本节介绍软件环境的设置以及如何构建工程。

3.1 安装MCUXpresso IDE

MCUXpresso是一款恩智浦提供的集成开发环境（IDE），用于编码、编译和调试，并继承了基于Eclipse的IDE的其他功能。

要安装MCUXpresso IDE，请执行以下步骤：

1. 访问恩智浦MCU的MCUXpresso IDE | Linux、Windows和MacOS | 恩智浦半导体|恩智普半导体，然后单击下载。

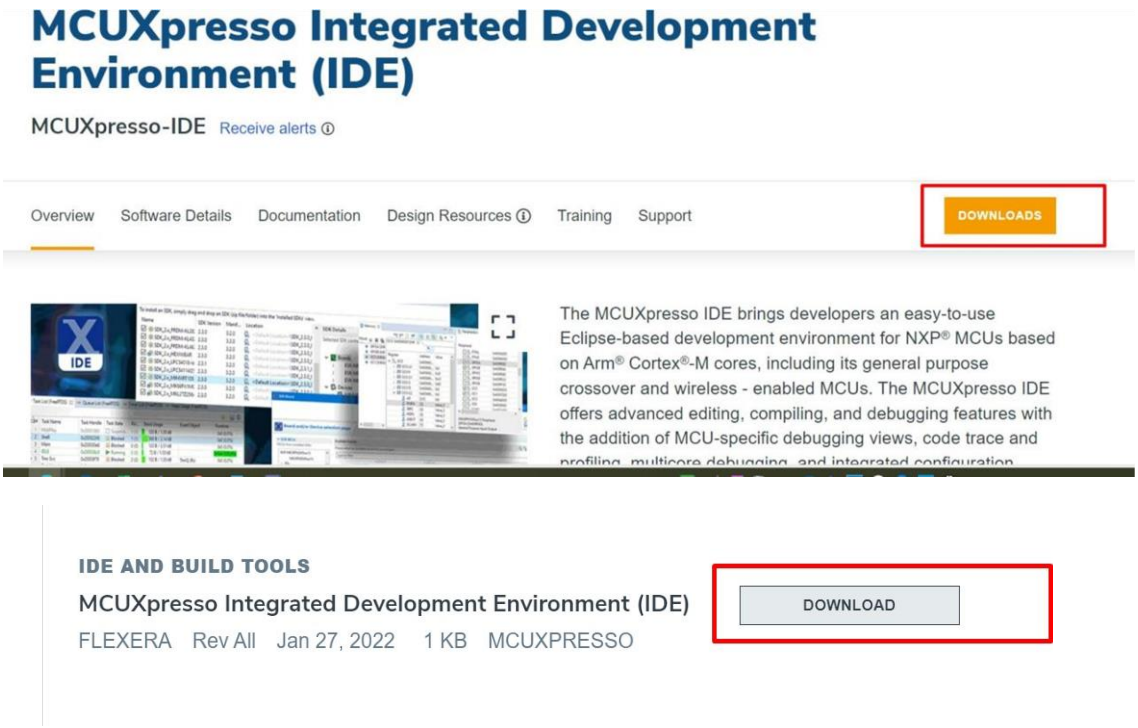

图7. 下载MCUXpresso IDE

2. 选择版本11.9.0。

图8. 选择版本11.9.0

3. 接受条款和条件，并根据您的操作系统选择相应的安装程序。

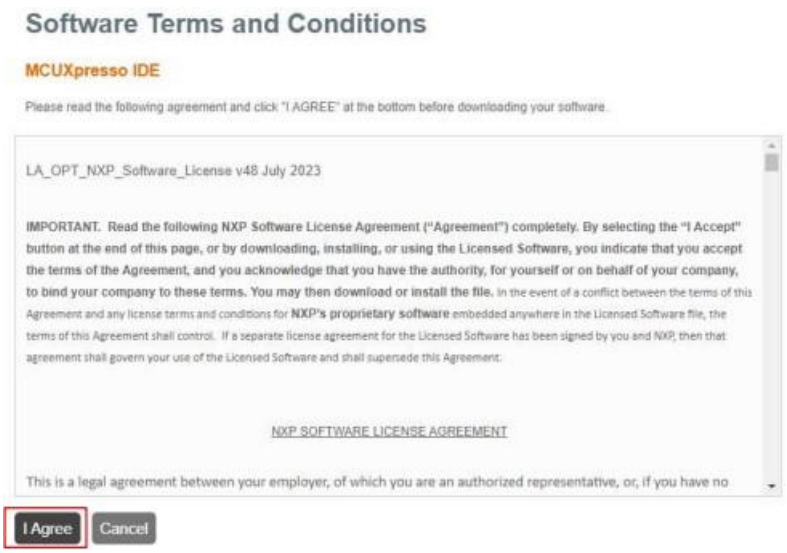

图9. 选择相应的安装程序

图10. 下载安装程序

4. 等待下载完成，然后运行安装程序。按照安装程序中的说明进行操作。

3.2 安装FRDM-MCXN947 SDK v 2.14

每个MCU都有自己的SDK，其中包括驱动程序、示例、中间件、文档和其他组件。要获取并构建演示，需要将SDK安装到IDE中：

1. 打开MCUXpresso IDE。转到欢迎页面，其中有一些快捷方式。点击“下载”并安装SDK。
   ***注：**如果未看到此窗口，请单击顶部选项卡中的“帮助”>“欢迎”（**Help > Welcome**）。*

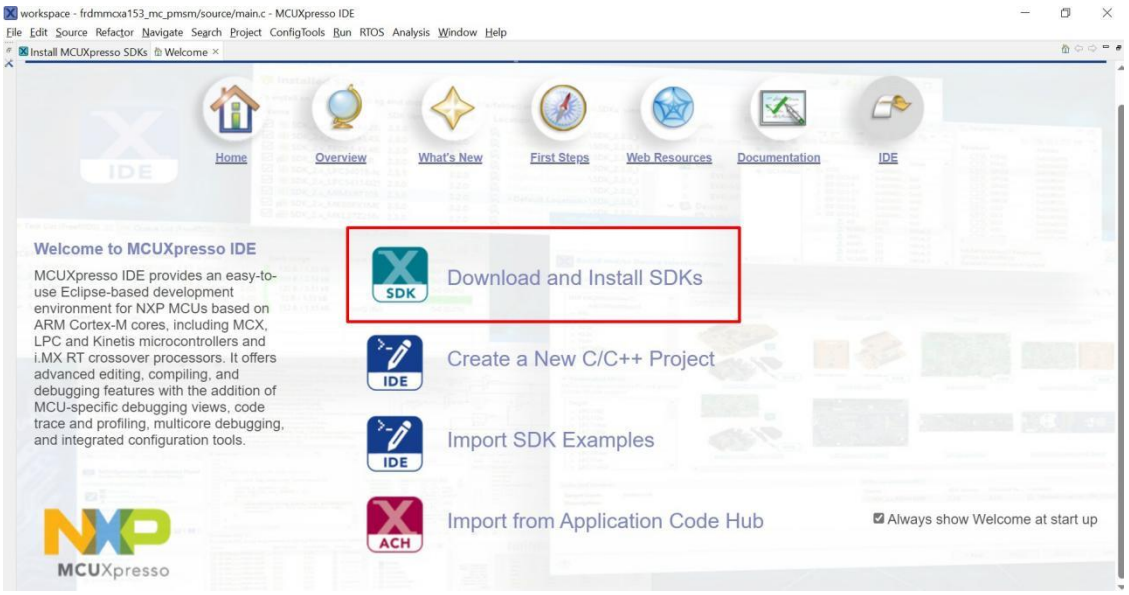

图11. 下载并安装SDK

2. 在“**筛选**”文本框中输入“MCXN947”，然后选择MCX N SDK，如图12所示。

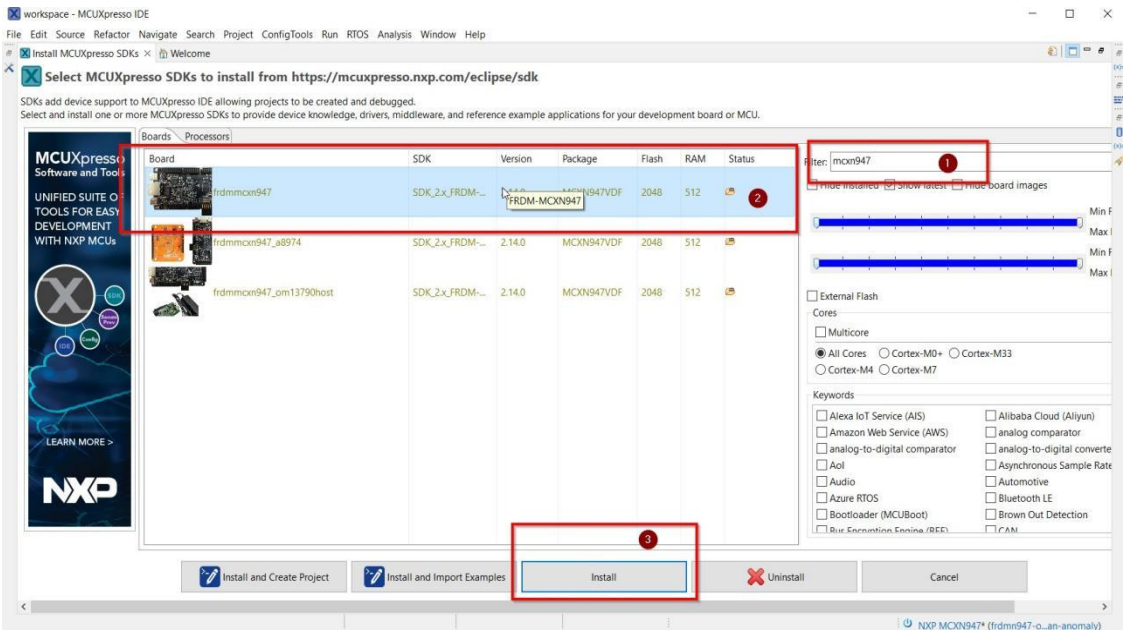

图12. 选择MCX N SDK

3. 单击“**安装**”并等待安装完成。
4. 从应用程序代码中心下载工程。

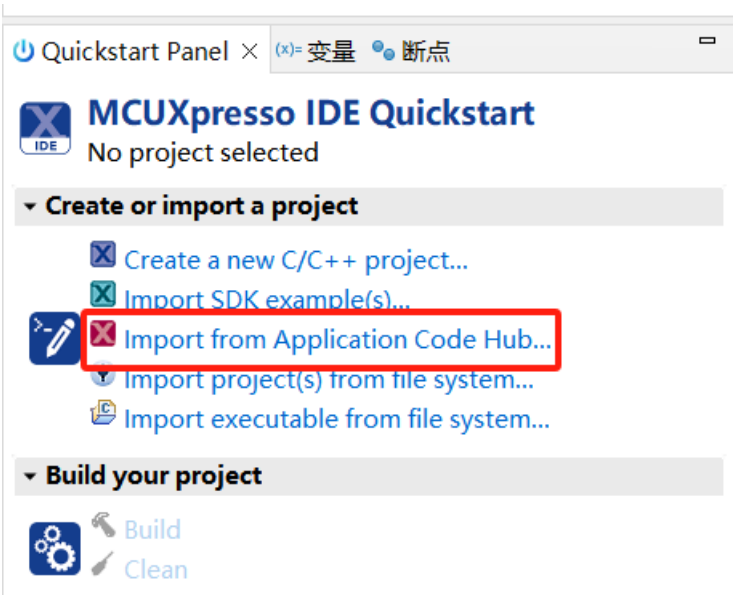

图13. 下载工程

5. 在文本框中输入“on-device training”，该工程将显示在列表中。

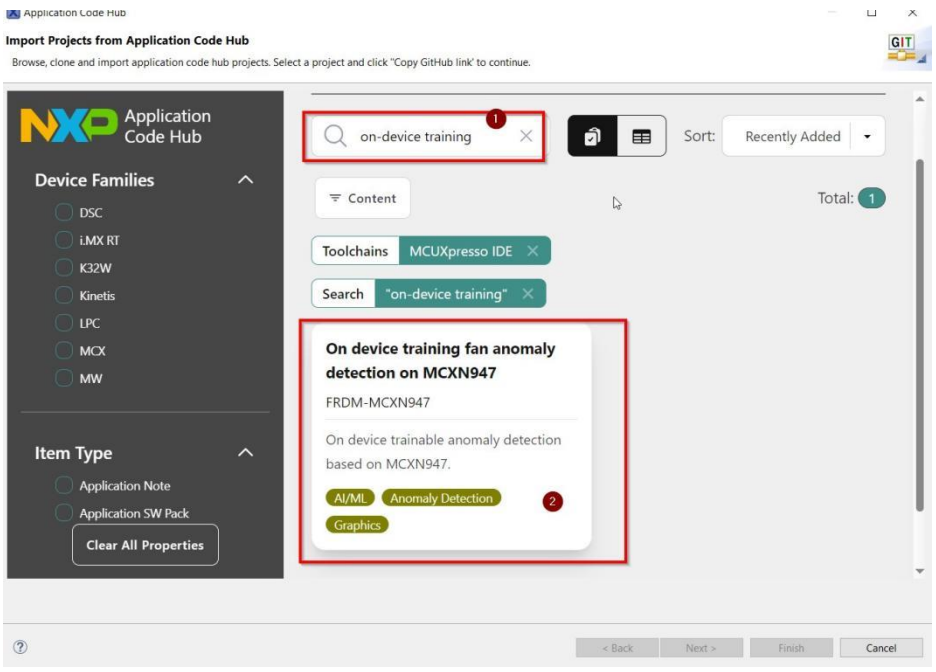

图14. 输入“on-device training”

6. 单击工程，窗口中会显示工程页面。

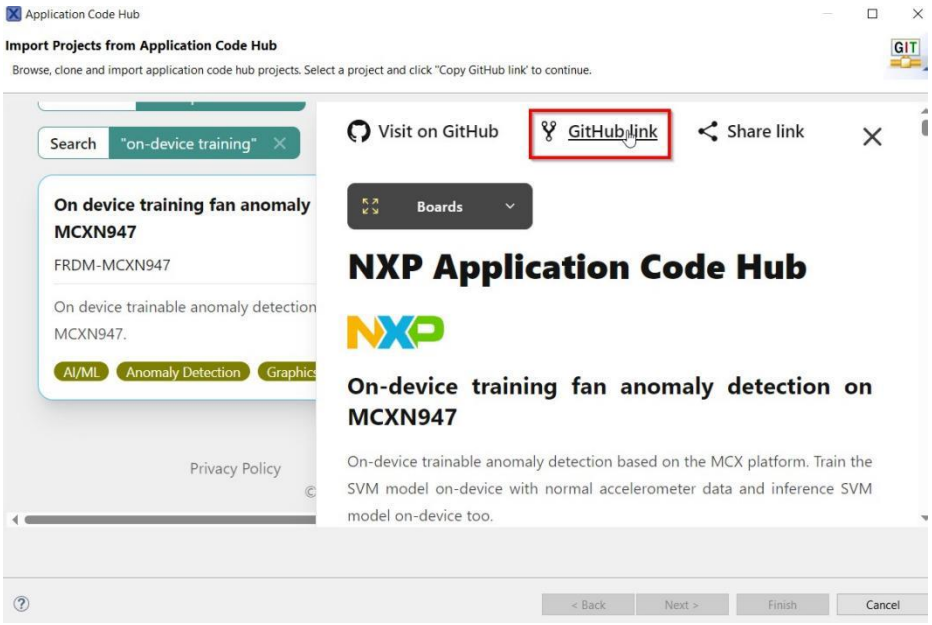

图15. 工程页面

7. 单击窗口顶部的GitHub链接，其中保存了工程的存储库。

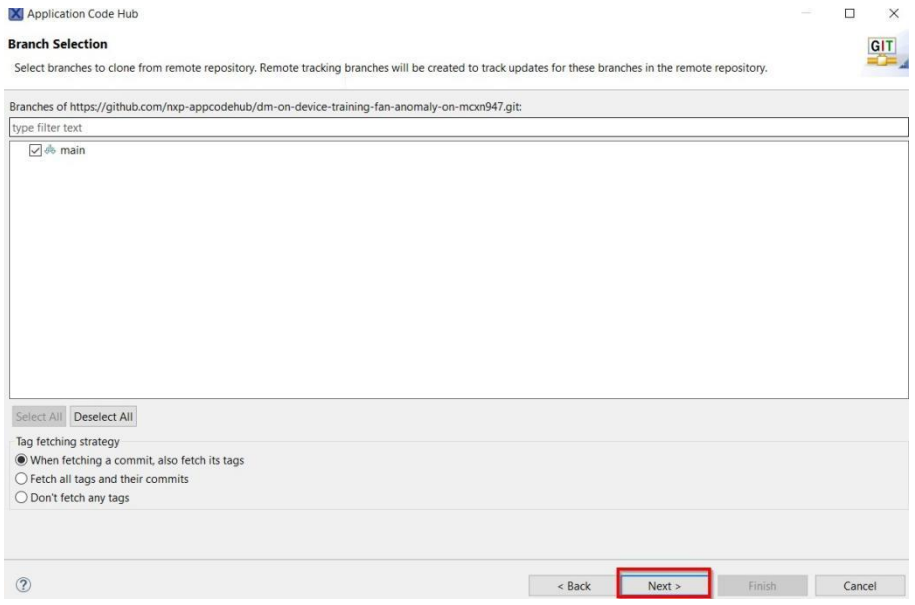

图16. 单击GitHub链接

8. 然后，单击底部的“**下一步**”按钮，从GitHub下载工程。

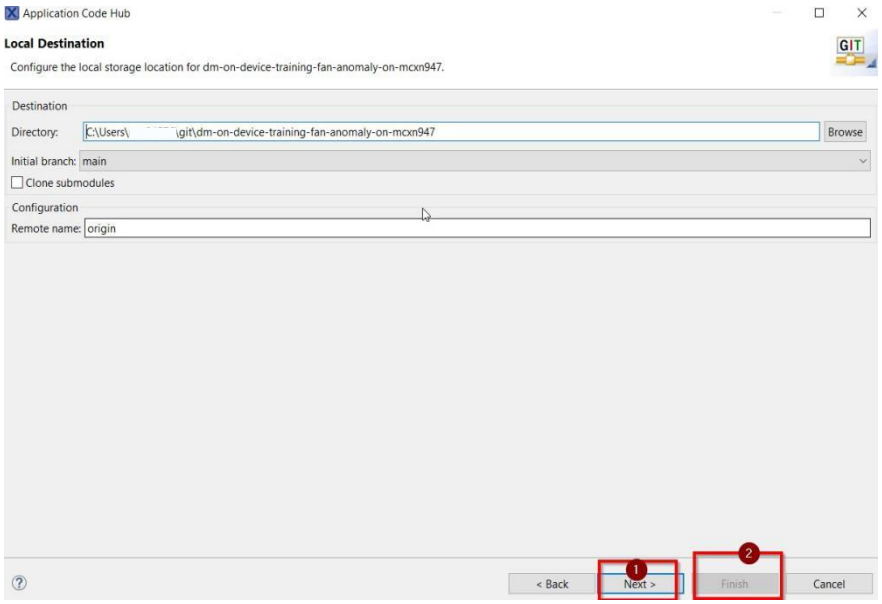

图17. 下载工程

9. 编译工程并将其加载到电路板上。

4 结果

本节介绍了如何运行此示例。

4.1 模型训练

要运行此训练模型，请执行以下步骤：

1. 打开风扇。单击“**训练**”按钮进入“Trainer”窗口。
2. 单击“**开始**”按钮开始训练模型。等待进度条加载完成。
3. 单击“**返回**”按钮。风扇的实时状态会显示在主窗口中。

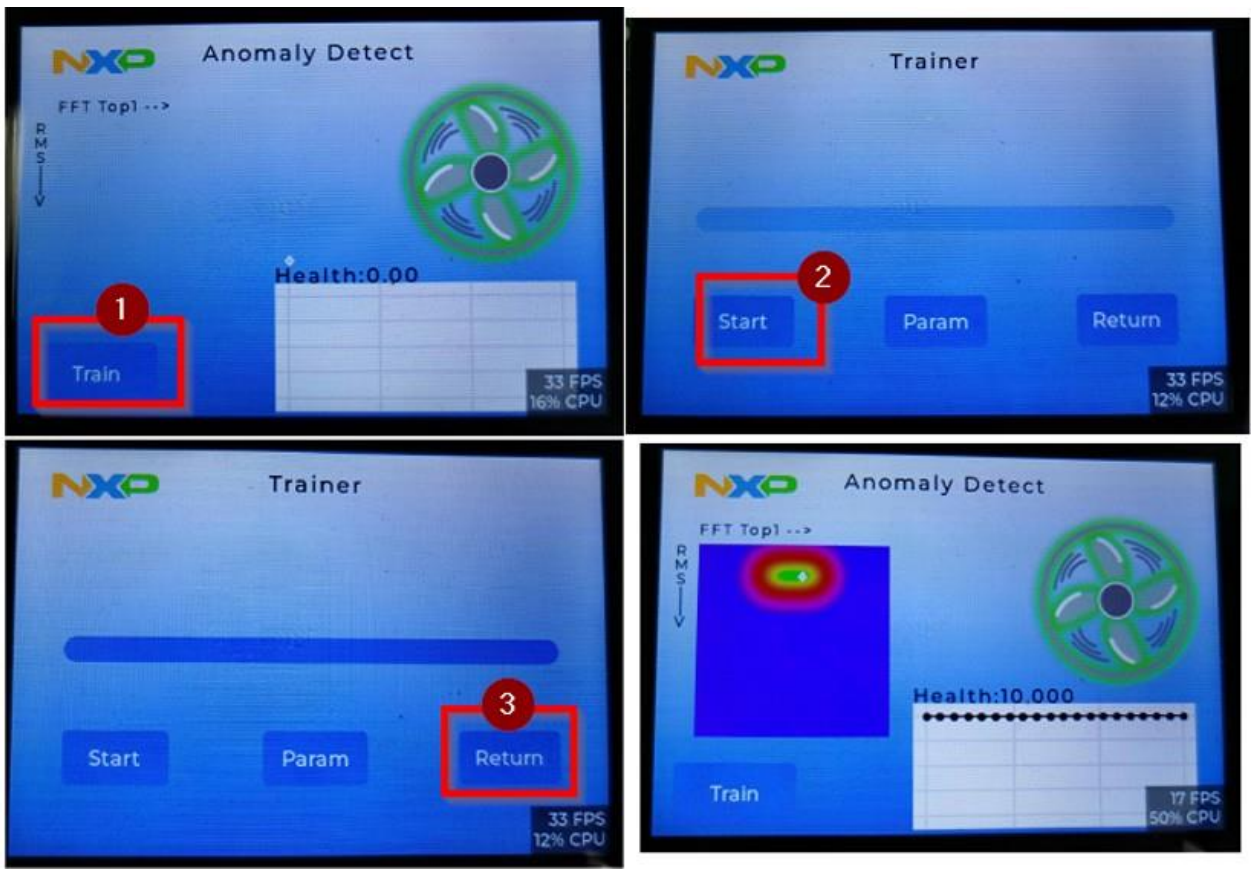

图18. 模型训练

4.2 模型预测

本节展示了模型训练的结果。

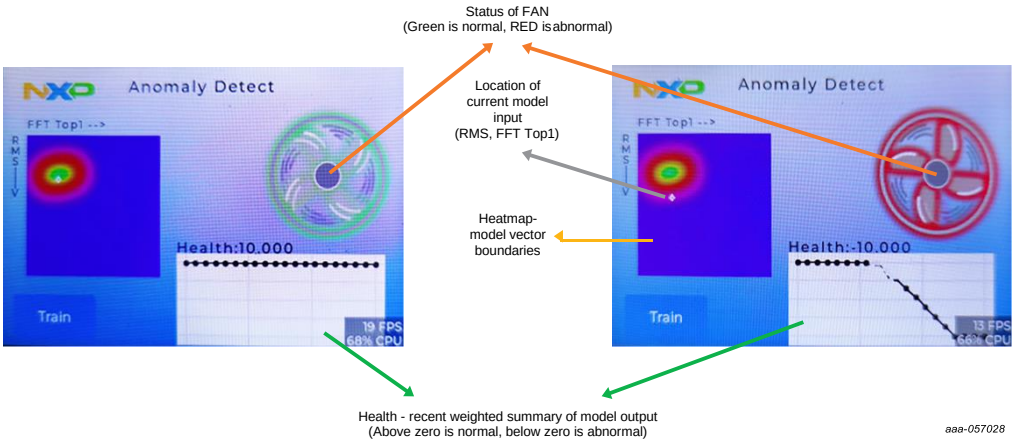

图19. 模型预测

4.3 高级训练

在“Trainer”窗口，用户可以在开始训练之前使用“**Param**”按钮更改参数，以获得一个更好的模型。此外，用户还可以启用“**增量训练**”，来基于当前的向量训练模型。

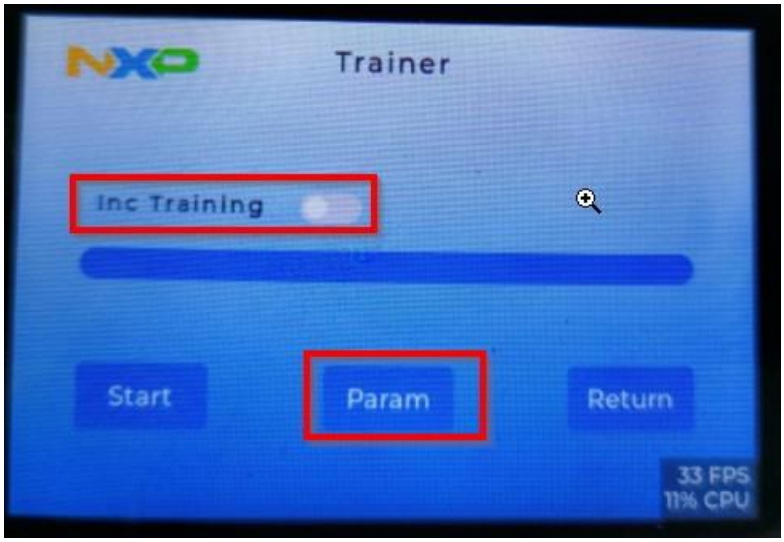

图20. Trainer窗口

参数设置

用户可以更改**Gamma**或**Nu**的值。

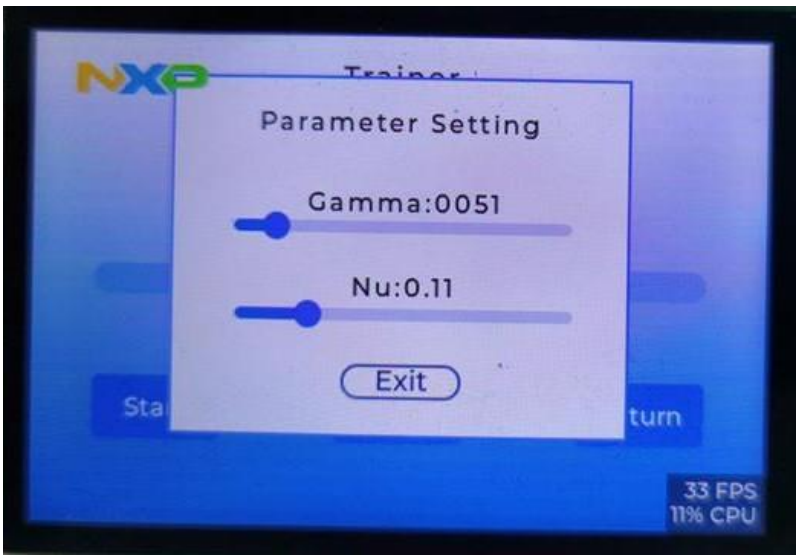

图21. 参数设置

增量训练

风扇/电机有时会以不同的速度工作，因此模型必须学习不同的特征。要基于当前的特征训练模型，需要在开始前启用“**增量训练**”。

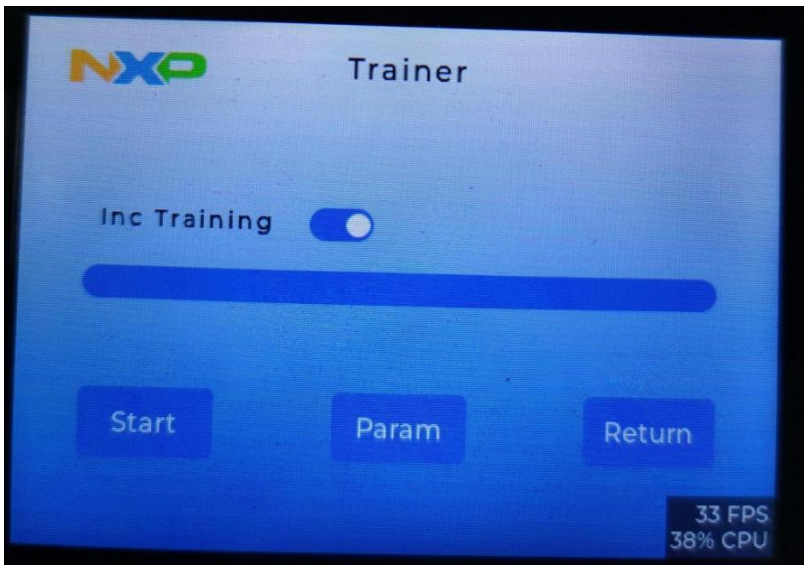

图22. 增量训练

要查看增量训练的效果，请执行以下步骤：

1. 在风扇速度为1时训练模型
2. 将风扇切换到速度2。则检测到异常。
3. 进入“Trainer”窗口。启用“**增量训练**”并再次开始训练。
4. 训练完成后，返回主窗口。则决策边界包括速度1和速度2。

图23. 增量训练的效果

4.4 异常情况

下面描述了几种异常情况：

- 有物体侵入风扇，干扰风扇叶片的运行。

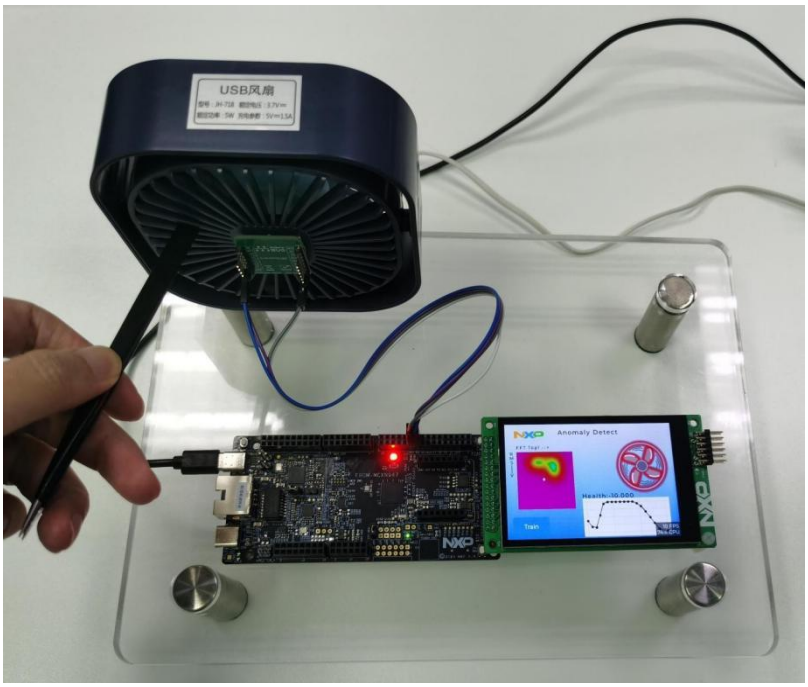

图24. 有物体侵入风扇

- 堵塞风扇的进气口。

图25. 堵塞风扇的进气口

- 抬起底座，导致风扇倾斜。

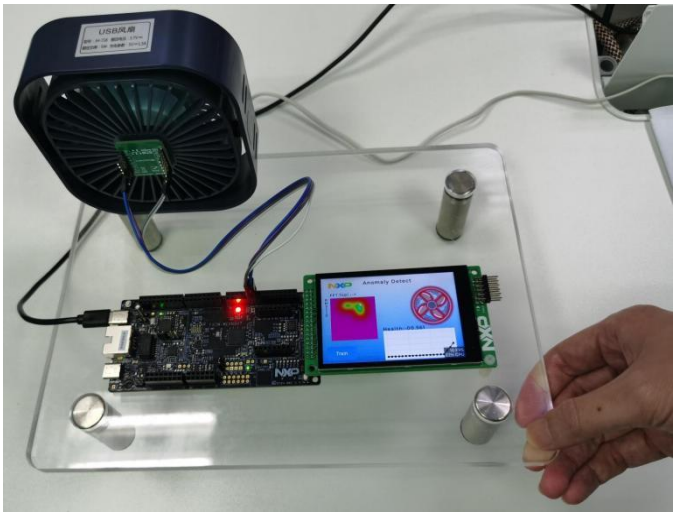

图26. 抬起底座

- 敲击底座引发异常振动。

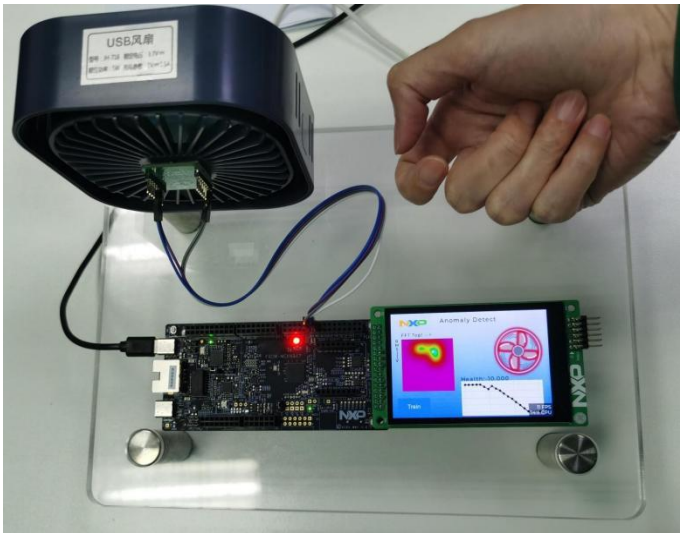

图27. 敲击底座

5 关于本文中源代码的说明

本文中所示的示例代码具有以下版权和BSD-3-Clause许可：

2024年恩智浦版权所有；在满足以下条件的情况下，可以源代码和二进制文件的形式重新分发和使用本源代码（无论是否经过修改）：

1. 重新分发源代码必须保留上述版权声明、这些条件和以下免责声明。
2. 以二进制文件形式重新分发时，必须在文档和/或随分发提供的其他材料中复制上述版权声明、这些条件和以下免责声明。
3. 未经事先书面许可，不得使用版权所有者的姓名或参与者的姓名为本软件的衍生产品进行背书或推广。

本软件由版权所有者和参与者“按原样”提供，不承担任何明示或暗示的担保责任，包括但不限于对适销性和特定用途适用性的暗示保证。在任何情况下，无论因何种原因或根据何种法律条例，版权所有者或参与者均不对因使用本软件而导致的任何直接、间接、偶然、特殊、惩戒性或后果性损害（包括但不限于采购替代商品或服务；使用损失、数据损失或利润损失或业务中断）承担责任，无论是因合同、严格责任还是侵权行为（包括疏忽或其他原因）造成的，即使事先被告知有此类损害的可能性也不例外。

6 修订历史

表1汇总了本文的修订情况。

表1. 修订历史

文档ID	发布日期	说明
AN14423 v.1.0	2024年9月10日	首次公开发布

Legal information

Definitions

Draft — A draft status on a document indicates that the content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included in a draft version of a document and shall have no liability for the consequences of use of such information.

Disclaimers

Limited warranty and liability — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors.

In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Terms and conditions of commercial sale of NXP Semiconductors.

Right to make changes — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

Suitability for use — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors and its suppliers accept no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

Applications — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect.

Limiting values — Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) will cause permanent damage to the device. Limiting values are stress ratings only and (proper) operation of the device at these or any other conditions above those given in the Recommended operating conditions section (if present) or the Characteristics sections of this document is not warranted. Constant or repeated exposure to limiting values will permanently and irreversibly affect the quality and reliability of the device.

Terms and conditions of commercial sale — NXP Semiconductors products are sold subject to the general terms and conditions of commercial sale, as published at https://www.nxp.com.cn/profile/terms, unless otherwise agreed in a valid written individual agreement. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NXP Semiconductors hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NXP Semiconductors products by customer.

No offer to sell or license — Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights.

Quick reference data — The Quick reference data is an extract of the product data given in the Limiting values and Characteristics sections of this document, and as such is not complete, exhaustive or legally binding.

Export control — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

Suitability for use in non-automotive qualified products — Unless this document expressly states that this specific NXP Semiconductors product is automotive qualified, the product is not suitable for automotive use. It is neither qualified nor tested in accordance with automotive testing or application requirements. NXP Semiconductors accepts no liability for inclusion and/or use of non-automotive qualified products in automotive equipment or applications.

In the event that customer uses the product for design-in and use in automotive applications to automotive specifications and standards, customer (a) shall use the product without NXP Semiconductors' warranty of the product for such automotive applications, use and specifications, and (b) whenever customer uses the product for automotive applications beyond NXP Semiconductors' specifications such use shall be solely at customer's own risk, and (c) customer fully indemnifies NXP Semiconductors for any liability, damages or failed product claims resulting from customer design and use of the product for automotive applications beyond NXP Semiconductors' standard warranty and NXP Semiconductors' product specifications.

HTML publications — An HTML version, if available, of this document is provided as a courtesy. Definitive information is contained in the applicable document in PDF format. If there is a discrepancy between the HTML document and the PDF document, the PDF document has priority.

Translations — A non-English (translated) version of a document, including the legal information in that document, is for reference only. The English version shall prevail in case of any discrepancy between the translated and English versions.

Security — Customer understands that all NXP products may be subject to unidentified vulnerabilities or may support established security standards or specifications with known limitations. Customer is responsible for the design and operation of its applications and products throughout their lifecycles to reduce the effect of these vulnerabilities on customer's applications and products. Customer's responsibility also extends to other open and/or proprietary technologies supported by NXP products for use in customer's applications. NXP accepts no liability for any vulnerability. Customer should regularly check security updates from NXP and follow up appropriately.

Customer shall select products with security features that best meet rules, regulations, and standards of the intended application and make the ultimate design decisions regarding its products and is solely responsible for compliance with all legal, regulatory, and security related requirements concerning its products, regardless of any information or support that may be provided by NXP.

NXP has a Product Security Incident Response Team (PSIRT) (reachable at PSIRT@nxp.com) that manages the investigation, reporting, and solution release to security vulnerabilities of NXP products.

NXP B.V. — NXP B.V. is not an operating company and it does not distribute or sell products.

Trademarks

Notice: All referenced brands, product names, service names, and trademarks are the property of their respective owners.

NXP — wordmark and logo are trademarks of NXP B.V.

目录