# *TI Designs：TIDEP-0102*
# *适用于保护继电器的人机界面 (HMI) 参考设计*

## 说明

这款基于处理器的参考设计有助于加快产品上市步伐，并帮助客户设计具有成本优势和人机界面(HMI)的保护继电器解决方案。此参考设计展示了对于保护继电器 HMI 而言常见的二维 (2D) Qt 图形用户界面 (GUI)，以及用于软件渲染图形的 TI 处理器功能。AM335x 处理器具有可扩展能力，提供一系列处理速度，使用同一软件开发环境来满足低端至高端 应用 的需求，并提供充足与关键外设的连接以保护继电器 HMI （如通用异步接收器/发送器 (UART) 和 CAN）。

## 资源

| | |
|---|---|
| TIDEP-0102 | 设计文件夹 |
| AM335x | 产品文件夹 |
| TMDSSK3358 | 工具文件夹 |
| PROCESSOR-SDK-AM335X | 工具文件夹 |

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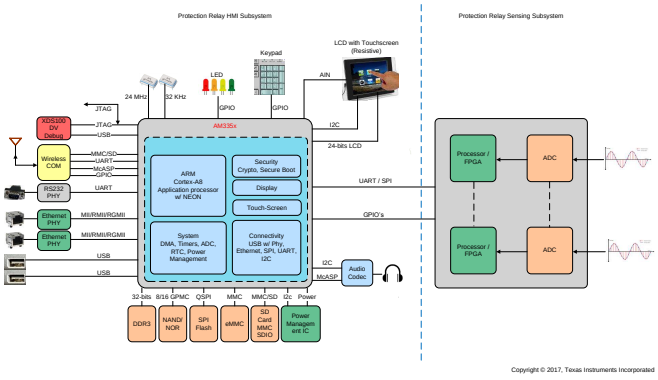
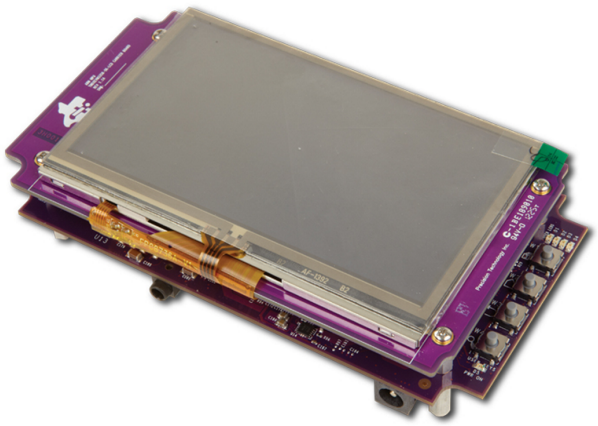
## 特性

- 保护继电器 HMI（使用软件加速图形和 Qt）的示例屏幕
- 支持电阻式触摸屏
- 在提供的 4.3 英寸 LCD 上支持 480×272 分辨率；在其他显示器上可扩展到 2048×2048
- 在 TI 的处理器 SDK-Linux 上构建以便于扩展到其他平台 Sitara™处理器

## 应用

- 保护继电器
- 变电站自动化
- 电能质量分析仪



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# 1 System Description

The worldwide electric-power infrastructure is a set of interconnected assets for power generation, transmission, conversion, and distribution, which is commonly referred to as *the grid*. Protection relays are used in the grid to measure a number of electrical parameters and take action as defined by the system integrator.

The protection relay system consists of sensing devices, analog-to-digital convertor (ADC) devices, a central processing unit (CPU) such as a microcontroller (MCU) or microprocessor (MPU), communication subsystems for both internal data exchange and external communications, and a human machine interface (HMI).

The Sitara™ AM335x processor, which is one of the most popular processors for industrial HMI applications, not only has the resources targeted for processing the user interface of a protection relay, but the AM335x processor's easy-to-use programming tools and on-chip capabilities give designers a head start on protection relay development projects.

Based on the AM335x starter kit evaluation module (EVM), the TIDEP-0102 reference design is a quick starting point for customers who want to design a protection relay HMI module or system for protection relay.

The TI AM335x processors are based on the Arm® Cortex®-A8 core (see Figure 1). These enhanced processors have rich peripherals and an advanced display capability, including 2-D and 3-D acceleration to help customers design cost-effective protection relay HMIs. The devices support high-level operating systems (HLOS) such as Linux, which is available free of charge from TI. The devices offer an upgrade to systems based on lower-performance Arm cores, provide updated peripherals, and support the typical interfaces, such as UART.


图 **1. Sitara™ AM335x Chip**

The AM335x processor supports 24-bit, liquid-crystal display (LCD) controllers with a resolution up to 2048 × 2048, which allows system designers to select various screen sizes and resolutions based on use cases and provides scalability from low to mid-end.

**(continued)**

The Qt framework is used to develop the GUI for protection relay HMI application software. Qt is a cross-platform application framework written in C++. Learn more about Qt at https://www.qt.io.

# 2 System Overview

## 2.1 Block Diagram

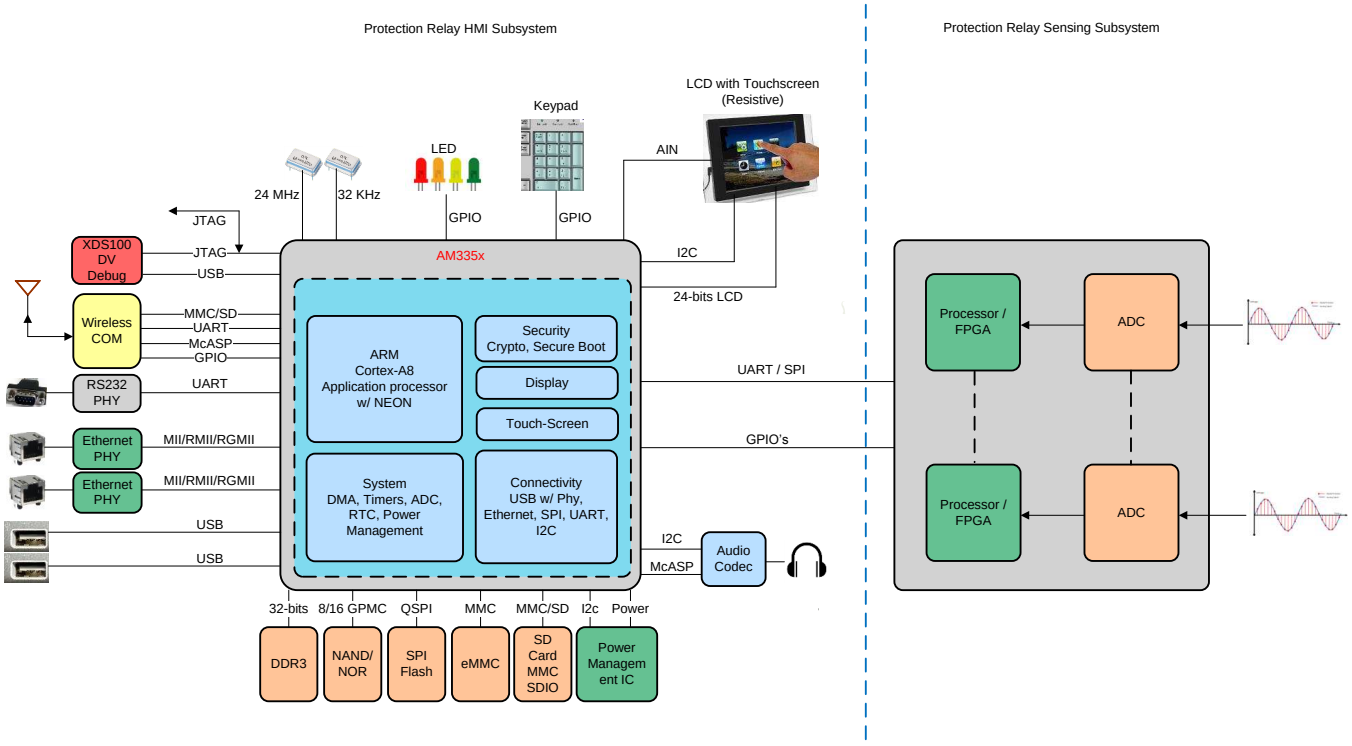





图 2. Protection Relay HMI Block Diagram

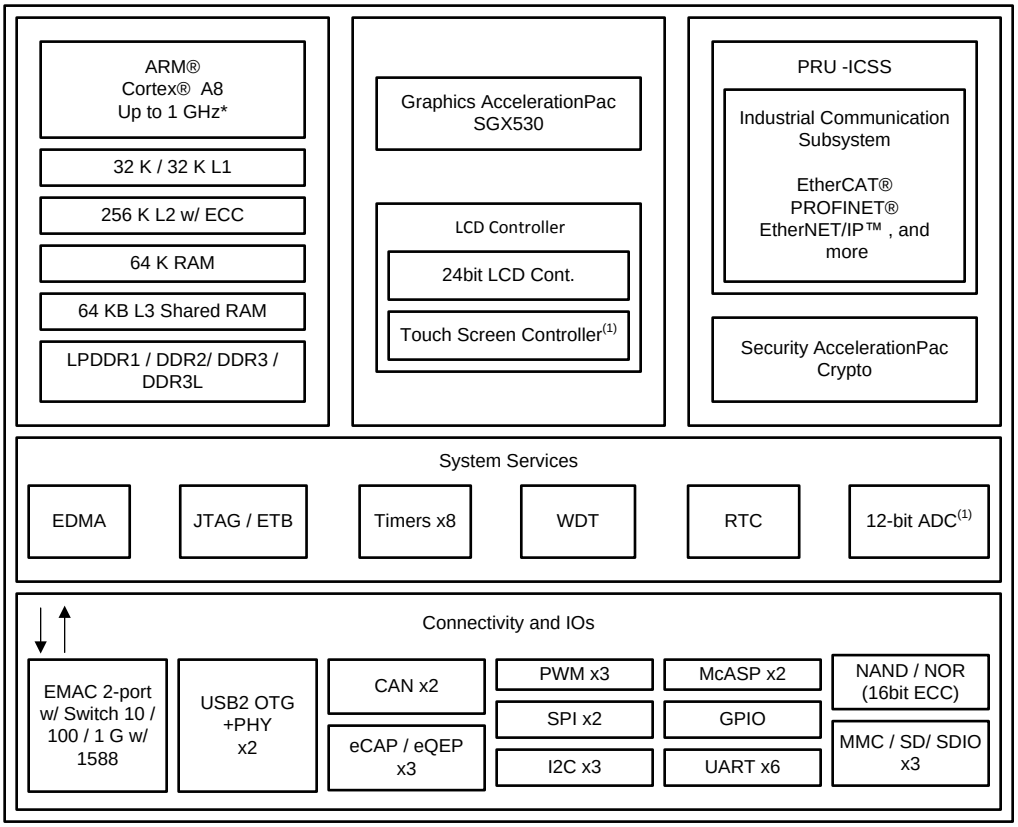
## 2.2 Highlighted Products

### 2.2.1 AM335x

The AM335x processors, based on the Arm Cortex-A8 core, are enhanced with image, graphics processing, peripherals, and industrial interface options, such as EtherCAT® and PROFIBUS®.

These devices support HLOS, such as Linux. The AM335x processors contain the subsystems in Figure 3: the microprocessor unit (MPU) subsystem, which is based on the Arm Cortex-A8 core, and the PowerVR SGX™, which is a graphics accelerator subsystem that provides 3-D graphics acceleration to support display and gaming effects.

The Programmable Real-Time Unit Subsystem and Industrial Communication SubSystem (PRU-ICSS) is separate from the Arm core and allows independent operation and clocking for greater efficiency and flexibility. The PRU-ICSS enables additional peripheral interfaces and real-time protocols, such as EtherCAT, PROFINET®, EtherNet/IP™, PROFIBUS, Ethernet Powerlink™, Sercos™, and others.




00 MHz / 1 GHz only available on 15 x 15 package. 13 x 13 support up to 600 MHz. Use of TSC will limit available ADC channels.



图 **3. AM335x Block Diagram**

Additionally, the programmable nature of the PRU-ICSS, along with its access to pins, events, and all system-on-chip (SoC) resources, provides flexibility in implementing fast, real-time responses, specialized data handling operations, custom peripheral interfaces, and in offloading tasks from the other processor cores of an SoC.

# 3 Hardware, Software, Testing Requirements, and Test Results

## 3.1 Required Hardware and Software

### 3.1.1 Hardware

The AM335x Starter Kit EVM is required to run the protection relay HMI demonstration application. The AM335x Starter EVM is a stand-alone test, development, and evaluation module system that enables developers to write software and develop hardware around an AM335x processor subsystem.

See the *AM335x Starter Kit Hardware User's Guide* for instructions on getting started and details on the hardware architecture of the AM335x Starter Kit EVM.

### 3.1.2 Software

The AM335x Processor SDK for Linux (Processor-SDK-Linux) provides a fundamental software platform for development, deployment, and execution of Linux-based applications. The protection relay HMI demonstration application source code is integrated in the Processor-SDK-Linux. The example application can be played through Matrix GUI application launcher. More information on Qt application development using Processor-SDK-Linux can be found in and .

The Processor-SDK-Linux package contains a software user's guide and additional documentation for setting up and running the demonstration applications. Download the package from www.ti.com/tool/PROCESSOR-SDK-AM335X.

For the purposes of this design guide, use a Linux host machine for the following instructions. With the required hardware, program the SD card with the Linux processor SDK image using the following steps:

1. Download the SDK installer ti-processor-sdk-am335x-evm-xx.xx.xx.xx-Linux-x86-Install.bin from TI.com (where *xx.xx.xx.xx* is the version number of the latest Linux processor SDK).
2. Create the SD card with default images using the *SDK Create SD Card Script* or see the user's guide.
3. Boot the Linux kernel and file system using the created SD card.

## 3.2 Testing and Results

### 3.2.1 Test Setup

This subsection provides details of the test setup with the required hardware and software to run the TI protection relay HMI software application.

1. Insert the micro SD card created in 节 3.1.2 in the location shown in Figure 4.
2. Insert the 5-V power supply and press the power button shown in Figure 4.

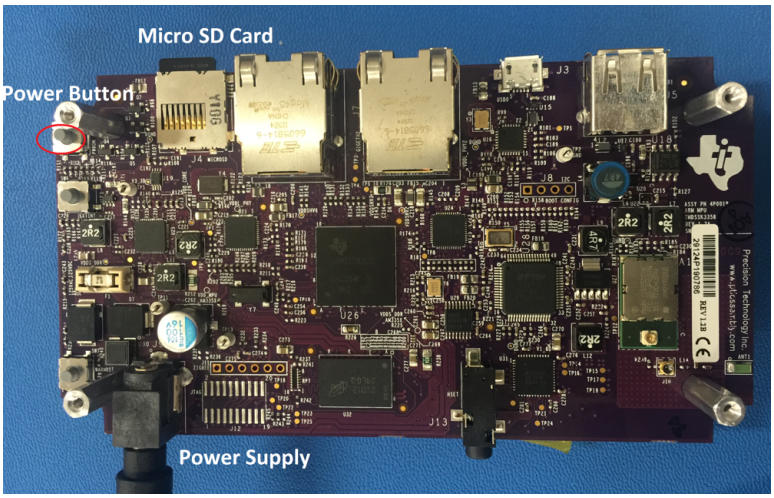



图 4. AM335x Starter Kit Setup (LCD Face Down)

3. The board boots up, the Matrix GUI application launches, and the interface shows on the LCD screen (see Figure 5).

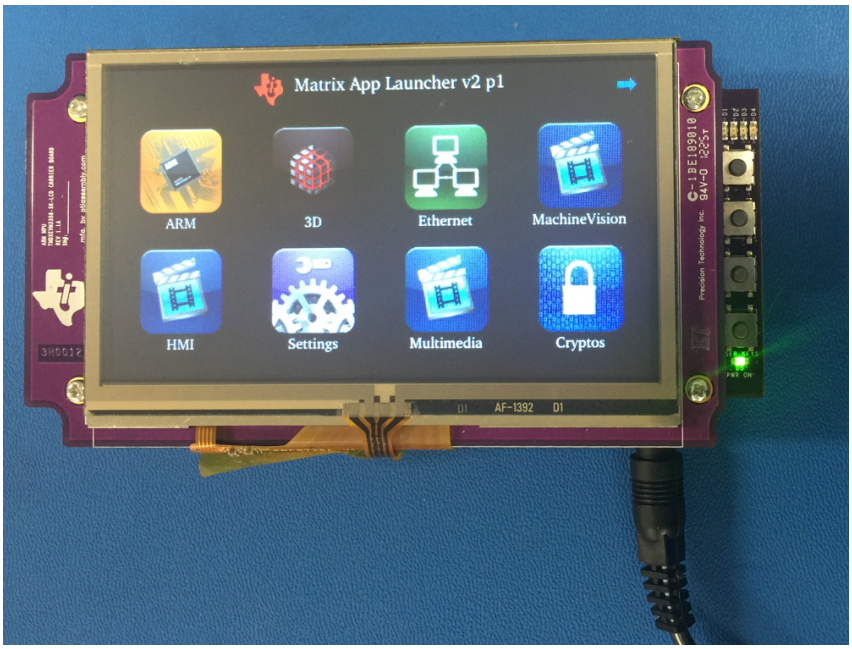



图 5. AM335x Starter Kit Setup (LCD Face Up)

### 3.2.2 Test Results

The test results are as follows:

1. Figure 6 shows the default Matrix GUI. Click on the *HMI* icon to navigate to the protection relay HMI demonstration.


图 **6. AM335x Default Matrix GUI**

2. Figure 7 shows the *HMI Submenu*, which is the next screen that appears. Click on the *PROTECTION_RELAYS* icon.


图 **7. HMI Submenu**

3. Figure 8 then shows on the screen. Click the *Run* button to launch the protection relay HMI demonstration GUI.


图 **8. Protection Relay HMI Description and Run Screen**

4. The protection relay HMI demonstration GUI launches and various example control icons are displayed on the screen (see Figure 9).
   - Click on any of the icon to go to the default action screen Figure 9.

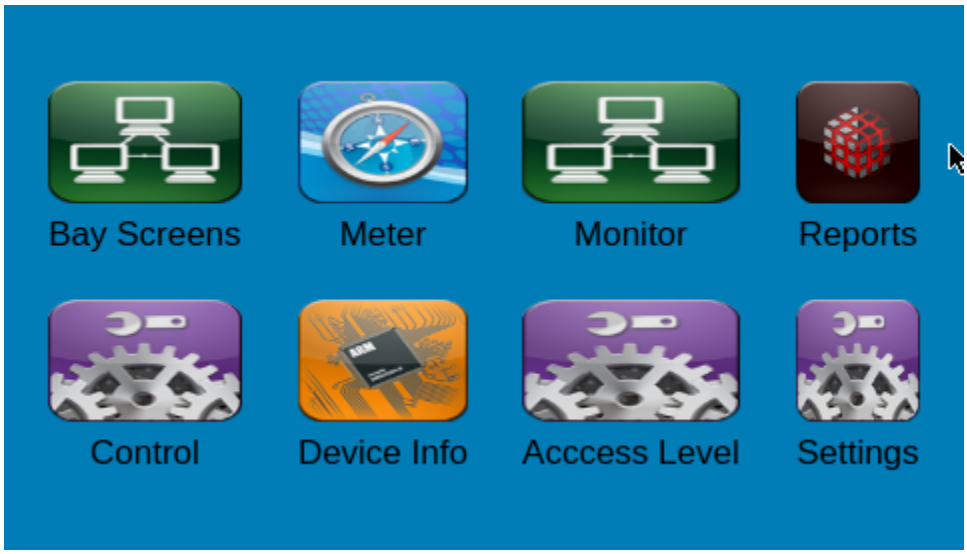
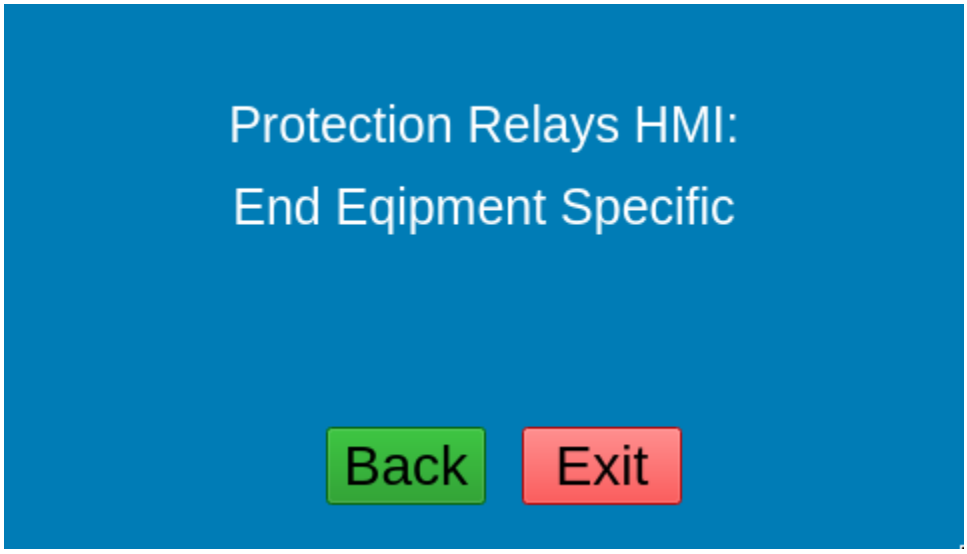



图 **9. Protection Relay HMI Demonstration GUI—Screen One**

5. Example action screen is shown with text displayed.
   - Click on *Back* button to go back to Figure 9
   - Click on *Exit* button to stop running the demonstration.




The *Exit* button on this screen is the only way to exit out of the demonstration GUI and return to the Matrix GUI.

**图 10. Protection Relay HMI Demonstration GUI—Screen Two**

## 4 Design Files

To download the hardware design files for the AM335x Starter Kit, see the design files at TIDEP-0102.

## 5 Software Files

Download the Processor SDK Linux for AM335x from the AM335x software product page.

## 6 Related Documentation

1. Texas Instruments, *AM335x Starter Kit Hardware User's Guide* , AM335x Wiki Page
2. Texas Instruments, *Qt Training: Multipage Resizable Graphical User Interfaces containing Media* , Application Report (SPRACB2)
3. Texas Instruments, *Sitara Linux Training: Hands on with QT* , Wiki Page
4. Texas Instruments, *Processor SDK Linux Software Developer's Guide* , Wiki Page
5. Texas Instruments, *Processor Linux SDK Graphics and Display* , Wiki Page

### 6.1 商标



## 7 Terminology

**EVM—** Evaluation module

**GUI—** Graphical user interface

**HLOS—** High-level operating systems

**HMI—** Human machine interface

**Protection Relay —** Electric vehicle supply equipment

**PRU-ICSS—** Programmable Real-Time Unit Subsystem and Industrial Communication SubSystem

**SDK—** Software development kit

**SoC—** System-on-chip

**UART—** Universal asynchronous transmitter/receiver

## 8 About the Author

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**MANISHA AGRAWAL** is part of Software Application team in the Catalog Processors BU. She has been with TI for more than 11 years and has worked on OMAP, DAVINCI and Sitara platforms. She is the Application lead for all the applications that includes video IPs such as capture, display, graphics, codec, and other video processing engine on these devices. Manisha earned her Master of Science in Digital Signal Processing from IIT, Kanpur, India.

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