TI Designs: TIDEP-0102
Human Machine Interface (HMI) for Protection Relay Reference Design

Description

This processor-based reference design facilitates a quicker time to market and helps customers design cost-effective, human machine interface (HMI) solutions for protection relay. This reference design showcases a two-dimensional (2-D) Qt graphical user interface (GUI), which is typical for protection relay HMI, along with TI processor capabilities for software-rendered graphics. The AM335x processors provide scalability by offering a range of processing speeds and using the same software development environment to satisfy low- to high-end applications as well as ample connectivity with the key peripherals required for protection relay HMI, such as universal asynchronous receiver/transmitter (UART) and CAN.

Features

- Example Screens of Protection Relay HMI Using Software-Accelerated Graphics and Qt
- Resistive Touchscreen Enabled
- Support for 480 × 272 Resolution on Included 4.3-in LCD; Scalable up to 2048 × 2048 on Other Displays
- Built on TI's Processor SDK-Linux for Scalability to Other Sitara™ Processors

Applications

- Protection Relay
- Substation Automation
- Power Quality Analyzers

Resources

TIDEP-0102	Design Folder
AM335x	Product Folder
TMDSSK3358	Tools Folder
PROCESSOR-SDK-AM335X	Tools Folder

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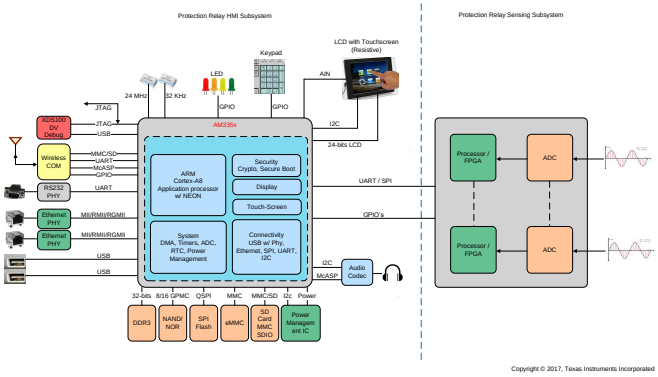

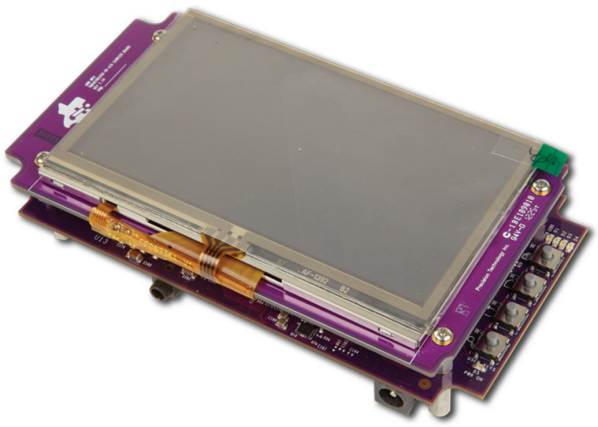

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1 System Description

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.

Figure 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.

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

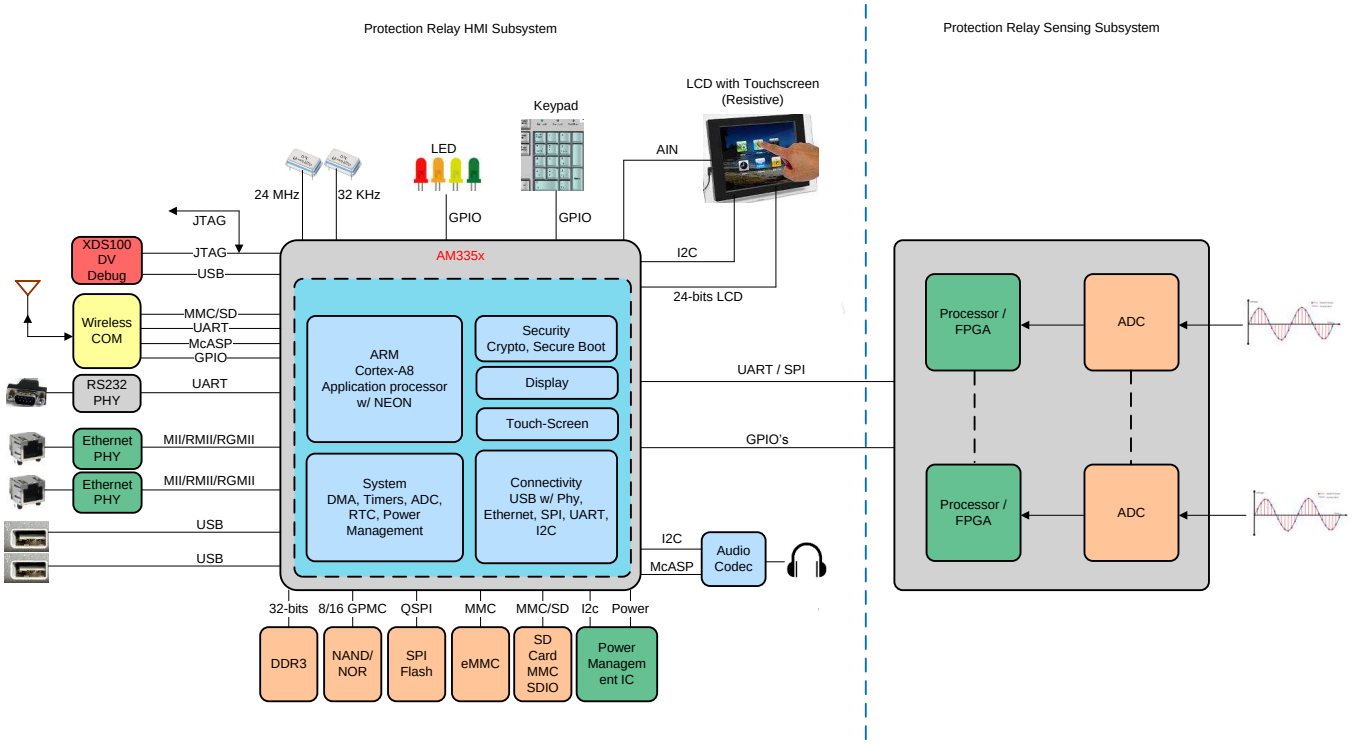


Figure 2. Protection Relay HMI Block Diagram

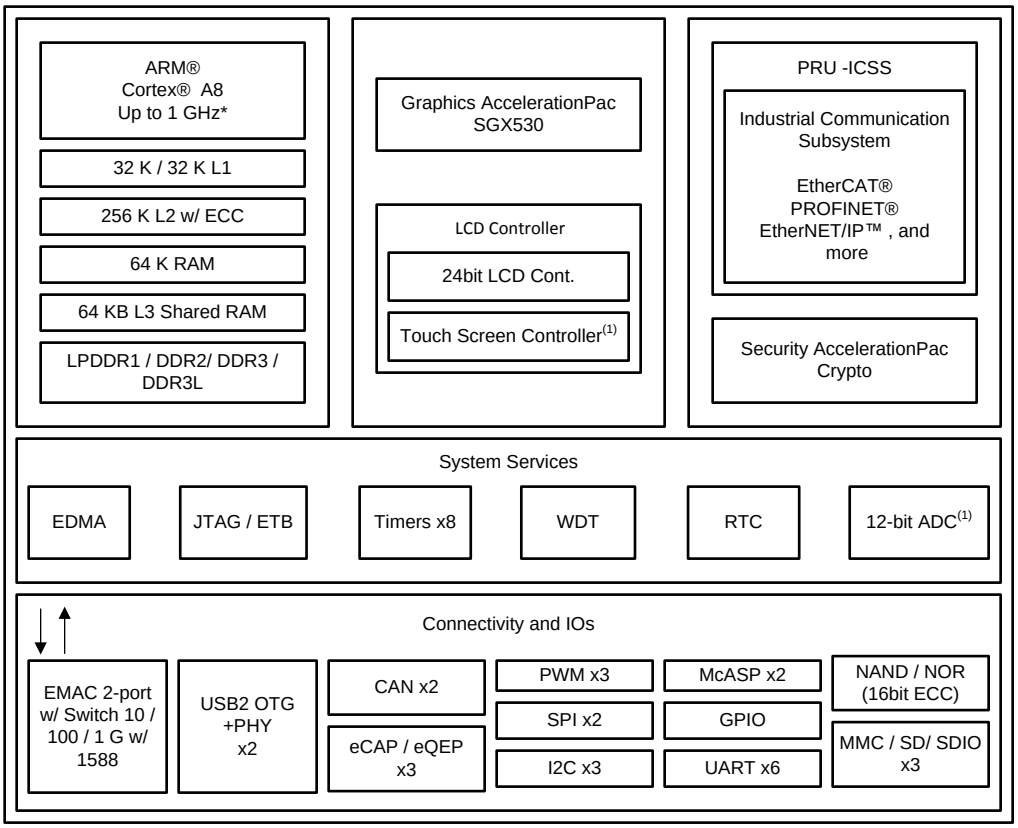
2.2 Highlighted Products

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.

Figure 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 Section 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.

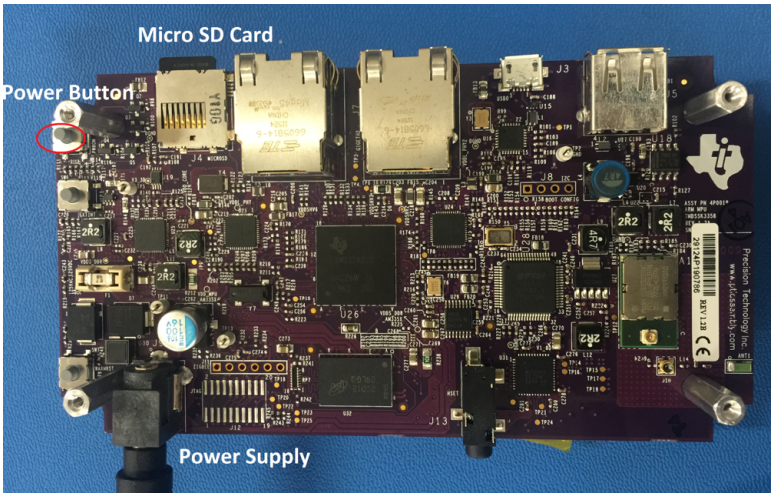


Figure 4. AM335x Starter Kit Setup (LCD Face Down)

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

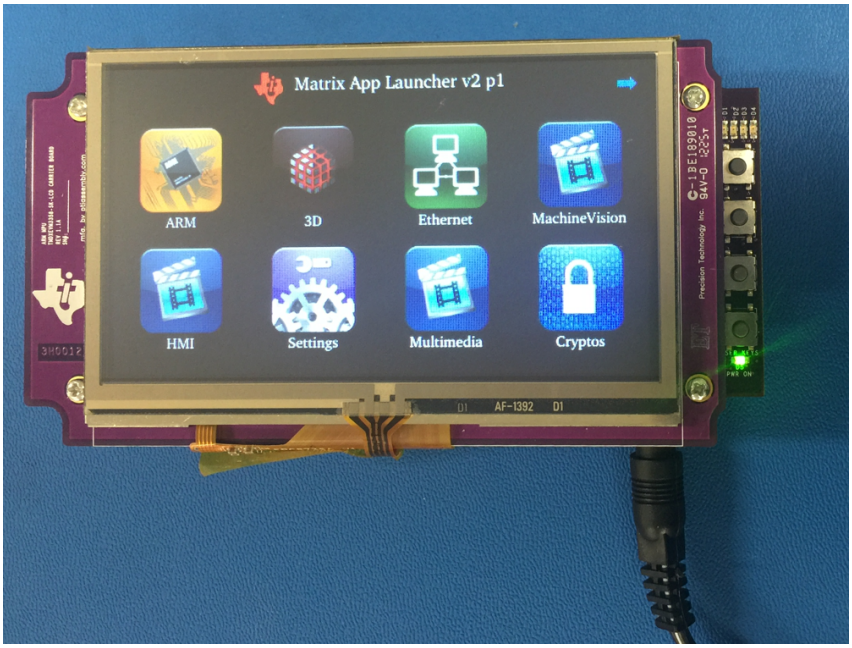


Figure 5. AM335x Starter Kit Setup (LCD Face Up)

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.

Figure 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.

Figure 7. HMI Submenu

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

Figure 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.

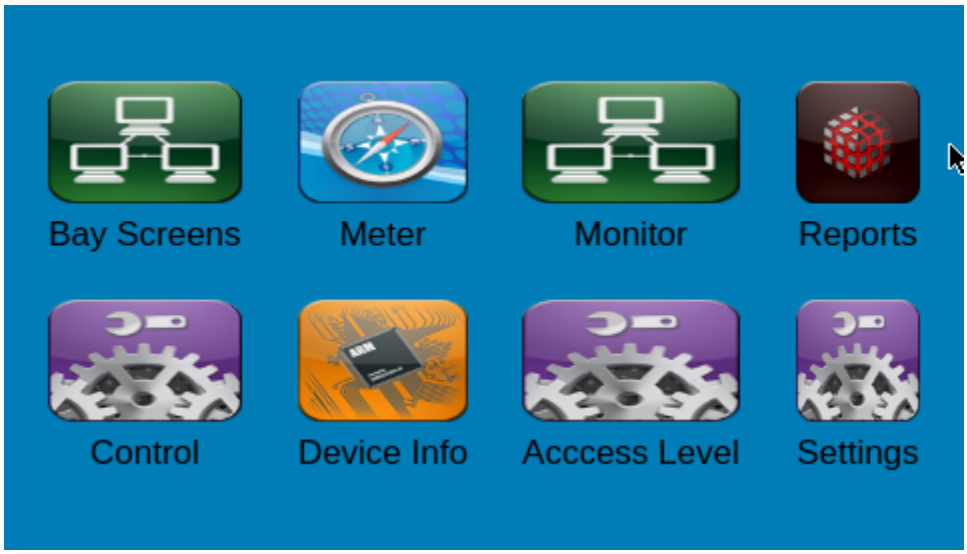
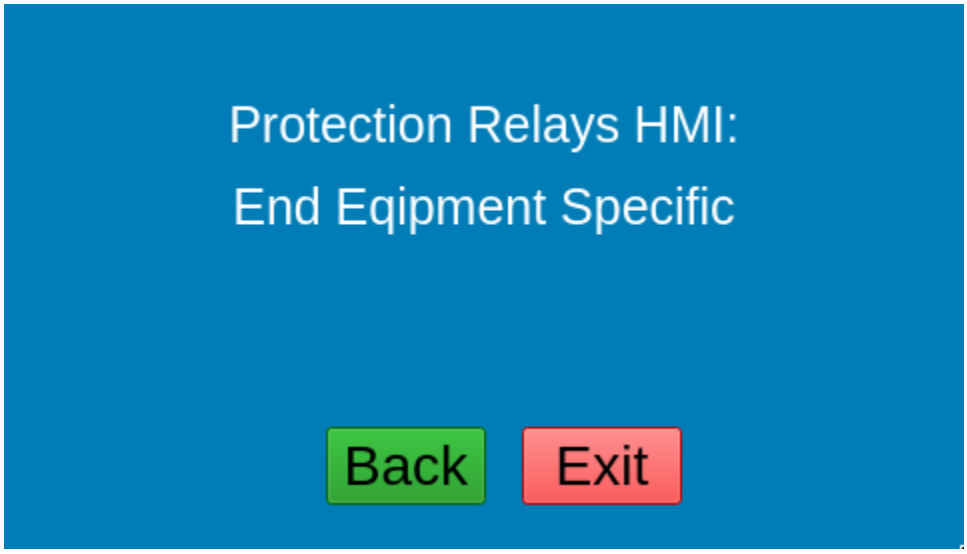


Figure 9. Protection Relay HMI Demonstration GUI—Screen One

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.

Figure 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 Trademarks

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

AMRIT MUNDRA is a part of System Team in Catalog Processors BU. He has been with TI for more than 14 years and has worked on multiple IPs and SoCs. He is the security architect for Keystone3 and security lead for Catalog BU. Amrit also is System lead for EPOS EE initiative in BU. Amrit earned his Master of Science in Electrical Engineering (MSEE) from SMU, Dallas, TX.

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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