TI Designs: TIDEP-0087

Human Machine Interface (HMI) for EV Charging Infrastructure 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 electric vehicle (EV) charging infrastructure or EV supply equipment (EVSE). This reference design showcases a two-dimensional (2-D) Qt graphical user interface (GUI), which is typical for EVSE HMI, along with TI processor capabilities for software-rendered graphics. The AM335x processors provide scalability with various processing speeds, compatible software to satisfy low- to high-end applications, and ample connectivity with the key peripherals required for EVSE HMI, such as universal asynchronous receiver/transmitter (UART) and CAN.

Features
- Four Example Screens of Charging Station Options 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
- EV Supply Equipment (EVSE)

Resources
TIDEP-0087 Design Folder
AM335x Product Folder
AM335x Starter Kit EVM Product Folder
AM335x SDK Software Product Folder

ASK Our E2E Experts

An IMPORTANT NOTICE at the end of this TI reference design addresses authorized use, intellectual property matters and other important disclaimers and information.
1 System Description

With increasing battery capacity and decreasing battery cost, electric vehicles are becoming more mainstream each day. The EVSE is an infrastructure element that supplies electric energy for the recharging of electric vehicles, such as plug-in electric vehicles, including electric cars, neighborhood electric vehicles, and plug-in hybrids.

The EVSE system consists of a power stage, some sort of central processing unit (CPU) such as a microcontroller (MCU) or microprocessor (MPU), communication subsystems for both internal data exchange and external communications, and an 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 charging station, but the AM335x processor’s easy-to-use programming tools and portfolio of on-chip capabilities give designers a head start on EVSE development projects.

Based on the AM335x Starter Kit Evaluation Module (EVM), the TIDEP-0087 reference design is a quick starting point for customers who want to design an EVSE HMI module or system for an EV charging infrastructure.

The TI AM335x high-performance 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 EVSE 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 to connect to EV charging power stages, such as UART and CAN.

![Sitara™ AM335x Chip](image)

**Figure 1. Sitara™ AM335x Chip**

The AM335x supports 24-bit, liquid-crystal display (LCD) controllers with a resolution up to 2048 x 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 EVSE HMI application software. Qt is a cross-platform application framework written in C++. Learn more about Qt at [https://www.qt.io](https://www.qt.io).
2 System Overview

2.1 Block Diagram

Figure 2. EVSE 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.

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

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 EVSE HMI demonstration.

![Figure 5. AM335x Starter Kit Setup (LCD Face Up)](image)

![Figure 6. AM335x Default Matrix GUI](image)
2. Figure 7 shows the HMI Submenu, which is the next screen that appears. Click on the EVSE icon.

![Figure 7. HMI Submenu](image)

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

![Figure 8. EVSE HMI Description and Run Screen](image)
4. The EVSE HMI demonstration GUI launches and the Welcome screen shows (see Figure 9).
   • The green Click to Continue button on the left navigates to the next page of the demonstration.
   • The orange Exit button on the right exits out of the demonstration and returns to the Matrix GUI in the previous Figure 6.

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

![Welcome Screen](image)

**Figure 9. EVSE HMI Demonstration GUI—Welcome Screen (Page One)**

5. The Click to Continue button in Figure 9 leads to the charging mode screen shown in Figure 10.
   • All four of the option buttons (Option 1 through Option 4) direct the user to the third page of the GUI.
   • The home icon in the bottom-right corner directs the user back to the Welcome screen in Figure 9.

![Charging Mode Screen](image)

**Figure 10. EVSE HMI Demonstration GUI—Charging Mode Screen (Page Two)**
6. **Figure 11** shows page three of the GUI.
   - The **Ok** button directs the user to the last page of the GUI.
   - The home icon in the bottom-right corner leads to the *Welcome* screen in **Figure 9**.

![Figure 11. EVSE HMI Demonstration GUI—Rate Period Setting Screen (Page Three)](image1)

7. **Figure 12** shows the last page in the demonstration.
   - After pressing the **Begin Charge** button, the progress bar, *Remaining Time* field, and *Elapsed Time* field begin updating.
   - The **End Charge** button directs the user back to the *Welcome* screen in **Figure 9**.

![Figure 12. EVSE HMI Demonstration GUI—Rate-Charging Metrics Screen (Page Four)](image2)
4 **Design Files**

To download the hardware design files for the AM335x Starter Kit, see the design files at TIDEP-0087.

5 **Software Files**

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

6 **Related Documentation**

2. Texas Instruments, *Qt Training: Multipage Resizable Graphical User Interfaces containing Media*, Application Report (SPRACB2)

6.1 **Trademarks**

Sitara is a trademark of Texas Instruments.
EtherCAT is a registered trademark of Beckhoff Automation GmbH, Germany.
Ethernet Powerlink is a trademark of Bernecker + Rainer Industrie-ElektronikGes.m.b.H..
PowerVR SGX is a trademark of Imagination Technologies Limited.
EtherNet/IP is a trademark of Odva, Inc.
PROFIBUS, PROFINET are registered trademarks of PROFIBUS and PROFINET International (PI).
Sercos is a trademark of Sercos International.

All other trademarks are the property of their respective owners.

7 **Terminology**

**EV**—Electric vehicle
**EVM**—Evaluation module
**EVSE**—Electric vehicle supply equipment
**GUI**—Graphical user interface
**HLOS**—High-level operating systems
**HMI**—Human machine interface
**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.
IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ("TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include, without limitation, TI's standard terms for semiconductor products http://www.ti.com/sc/docs/stdterms.htm), evaluation modules, and samples (http://www.ti.com/sc/docs/sampterms.htm).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2017, Texas Instruments Incorporated